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José Luis Cendejas, Juan Enrique Castañeda and Félix-Fernando Muñoz

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Business cycles and monetary regimes in the U.S. (1960 – 2014): A plea for monetary stability

José Luis Cendejas[1] · Juan Enrique Castañeda[2] · Félix-Fernando Muñoz[3]

Abstract: It is still highly debated whether the Fed took sufficiently into account the rapid increase in both financial and real asset prices as well as money growth in the framing of monetary policy decisions in the years prior to the outbreak of the Global Financial Crisis; something similar occurred in the 1970s as regard the slow and insufficient response of the Fed to the growth of CPI prices. In our view, these two episodes are prime examples of how the absence of a more comprehensive monetary strategy has resulted in a case-by-case decision-making policy by the Fed lacking in consistency and effectiveness over the long term. In this respect, two elements of the central bank strategy become key: the choice of the information set the monetary authorities process and use to make policy decisions and the (main) economic model used to process that information. In this paper we consider a wide range of indicators to identify the dynamics and interaction between several output and price indicators (broadly defined to include CPI, industrial and asset prices) along the business cycle. In particular, we adopt unobserved component models to estimate and analyse the cyclical common factors of output measures, inflation and asset prices, interest rates (both short and longer term), and narrow and broad money growth measures, since 1960 to 2014 in the US. Once estimated, we analyse the correlations between these common factors and their changes in order to identify common behavioural patterns amongst them along the cycle. This analysis will result in a 'core information set' for the Fed suitable to frame and possibly implement a more stable monetary policy throughout the business cycle.

Keywords: US business cycle, US monetary policy regimes, money and inflation, central bank strategy, cyclical common factors, core information set

JEL: C32, E32, E52

(1) Universidad Francisco de Vitoria. Ctra. Pozuelo-Majadahonda Km. 1,800. 28223 Pozuelo de Alarcón. Madrid (SPAIN)
E-mail: jl.cendejas@ufv.es

(2) Economics and International Studies Department. Hunter Street campus. Buckingham, MK18 1EG. (UNITED KINGDOM)
E-mail: juan.castaneda@buckingham.ac.uk

(3) Departamento de Análisis Económico: Teoría Económica e Historia Económica. Universidad Autónoma de Madrid. C/ Francisco Tomás y Valiente 5. 28049 Madrid (SPAIN)
E-mail: felix.munoz@uam.es

1. Introduction: Money and the framing of monetary policy

Since the collapse of the Bretton Woods fixed exchange rate system in the early 1970s, an extensive literature and research in the field has supported the adoption of a rule-based monetary policy strategy to better stabilise both inflation and output along the cycle, so that the policy maker avoids inconsistent and self-defeated discretionary policies to achieve policy gains in the short run at the expense of less output and prices instability over the long term. The Bretton Woods system was able to provide a nominal anchor during nearly three decades in the after-war period aimed at maintaining the parities of the world currencies against the US$. This commitment prevented national central banks from running discretionary or inflationary policies that could jeopardise the fulfilment of the established parity of the national currency against the dollar. However, the running of quite expansionary economic policies in the US as well as the financial cost of the war in Vietnam resulted in the so-called twin deficit scenario which threatened more and more the US position as guarantor of a world monetary system, ultimately based on the purchasing power of the dollar. In that scenario,[1] and once the US abandoned its commitment to maintain the gold parity of the dollar in 1971, the Fed regained the range of manoeuvre to run an independent monetary policy to tackle with the increasing inflation at the time; instead, following a discretionary fashion, from 1971 until 1979 the Fed accommodated its policy to the increasing inflationary environment and thus did not take a firm policy to bring back inflation to its pre-oil crisis rates. According to the estimates and analyses made later on, this corresponds to a period explained by the running of a non-anti-inflationary 'Taylor rule in the shadow', given the insufficient weight given to CPI growth and inflationary expectations at the time. The combination of an expansionary fiscal policy since the 1960s and the adoption of a too expansionary monetary policy in the 1970s in the midst of a negative supply shock (the first oil crisis) resulted in both high inflation and output losses and greater instability in the US economy for nearly a decade.

The appointment of Paul Volcker as the new Chair of Governors of the Fed inaugurated a new monetary strategy based on tackling inflation much more firmly by targeting the rate of growth in banks' reserves compatible with price stability. Inspired by the 'monetarist revolution' at the time, the actual policy priorities of the Fed changed in favour of price stability, which relied on the correlation between the monetary base and broader money growth measures and prices over the medium and the long term. However, far from the mechanical application of the money

[1] We have mainly used the excellent surveys written by Bordo and Schwartz (1999) and Benati and Goodhart (2010) for this brief introduction of the main policy milestones of the US monetary policy strategy since 1960 onwards.

quantity equation, the Fed followed a strategy mainly informed by the growth of the monetary base but also by other monetary and real indicators.[2] The committed and systematic application of this new strategy from 1979 until 1982 brought out the intended policy goal, namely, the successful control of inflation. As extensively supported by the academia at the time (Kydland and Prescott, 1977, and several years later by Barro and Gordon, 1983) a more credible policy-maker, in charge of a rule-based policy committed to keeping inflation in check, could achieve its policy goals more effectively an at a lower cost in terms of output. As it will be shown later in the paper (section 3 below), targeting the monetary base was accompanied by greater interest rates variations (the endogenous variable in the Fed's new monetary strategy), and the cut in the amount of money in circulation did tackle inflation but also provoked an initial contraction in output.

The alleged more volatility of the demand for money in the early 1980s put an end to the 'practical monetarism' strategy of the Fed and paved the way to a more pragmatic approach characterised by the implicit running of an anti-inflationary Taylor rule, one where inflation has become the overriding policy goal at least until 2007 (see Taylor, 1993; Clarida *et al.*, 1999).[3] From 1983 onwards, the Fed has been targeting (explicitly after 1994) a nominal very short run interest rate, the Fed Funds rate. As a consequence of this change in the Fed's strategy, monetary aggregates have become more and more endogenous (and thus more volatile in the short run) as their supply will ultimately depend on the demand of different forms of liquidity by households, financial and non-financial institutions. These were the more than twenty-year time period of the Great Moderation (or the NICE[4] years as put by the then Governor of the Bank of England, Mervyn King, in 2003 referring to the UK economy), characterised by sustained economic growth and quite low CPI inflation until 2007.

However, as discussed below in more detail, this benign macroeconomic environment showed early signals of potential instability when broad money aggregates started to grow well above those levels compatible with price stability since the early and mid-2000s until 2007 in the US as well as in the most developed world economies.

[2] In fact, as discussed as regards the application of monetarist rules in other countries such as Germany in the same time period (see Bofinger, 2001 and Beyer et al., 2013), central banks did not applied a rigid rule committed to correct any deviation of the base in relation to the target; but they rather followed a more flexible rule however mainly informed by changes in money growth, thus adopting a 'practical monetarism' strategy.

[3] These works amongst many others at the time assessed the bias of the Fed ex post by estimating the so-called reaction coefficients of the central bank; the consensus showed an anti-inflationary Fed's policy since the end of the oil crises, as far as the estimated values fulfil the 'Taylor principle' by which nominal interest rates change more than proportionally to deviations of inflation from target.

[4] Non-Inflationary Consistently Expansionary.

Since 2007, and particularly from 2008 to 2014, the Fed has been embarked in a succession of highly discretionary policy changes to tackle the effects of a major financial crisis. The role of the Fed as the lender of last resort of the financial system has determined its new policy priorities in terms of the practical provision of unlimited liquidity to banks and the rescue of the financial system rather than price stability (quantified since 2012 as a 2% annual rate of CPI inflation); and for that purpose the Fed has cut down its policy rate to its minimum and implemented a wide variety of new open market operations (see Fawley and Neely, 2013, for a summary of them) to both inject more money in monetary and financial markets and to provide easy financing to the Government and financial institutions.

Well before the outbreak of the recent Global Financial Crisis (GFC), most central banks disregarded the use of money in the framing of monetary policy decisions. The Fed abandoned the publication of M3 figures in 2006 and has implicitly followed a Taylor type rule very well grounded in the mainstream macroeconomic models used in academia and by the central banks' research departments (see, for example, Woodford, 2008). As shown in McCallum and Nelson (2010), the current models where monetary aggregates play no explicit role in explaining inflation may be optimal only under quite demanding conditions, such as the perfect substitution of the different assets in the demand for money function. As evidenced in the years prior to the recent crisis, the returns coming from the real estate sector in many developed economies did well exceed those of the public debt and other alternative assets, attracting an exceptional inflow of capital into that economic sector (see Bordo & Jeanne 2002). In addition, there is an extensive research showing the empirical relationship between above-normal money growth or a too low interest rates policy and inflation in asset prices (see Congdon, 2005; and Bordo and Landon-Lane, 2013), as well as on the usefulness of monetary aggregates to anticipate inflation over the medium and the long term (Carstensen, 2007; Christiano *et al.*, 2008; Fisher *et al.*, 2008; Hofmann, 2008; Benati, 2009; Dreger and Wolters, 2013).

The analysis of the policy stance of the Fed in the immediate years prior to the recent crisis is still a quite controversial issue (Beckworth and Ponnuru, 2011; Blinder, 2013): on the one hand, we have those claiming that the abundance of liquidity was an international-led phenomenon triggered by the exceptional increase in savings in the new emerging economies (the so-called 'savings glut' hypothesis by Bernanke, 2005); and on the other hand those claiming that the Fed followed a too loose monetary policy for too long and that this contributed to the generation of the financial crisis (Taylor, 2009; Selgin *et al.*, 2015). Even though related to this debate, our approach is different. We do not assess how loose or tight the Fed's monetary policy was before the crisis, but we take a step back to analyse in the first place the usefulness of a *core* *information set* to inform about price and activity developments over the short and the long term, and thus be able to draw policy recommendations.

This paper contributes to the analysis of the relationship between monetary regimes and business cycles in the US economy. To this end, we model and analyze, by means of common factor models, the cyclical behaviour of a vector of variables fundamental for monetary policy making purposes along the time, i.e. a core information set. Within our models, and by doing an analysis from 1960 to 2014, we will be able to identify the relationship and dynamics between the business cycle and the monetary policy variables. To do this, firstly, we identify six cyclical common factors from a broader set of variables to obtain synthetic information on the business cycle, inflation, interest rates (both short term and across the entire maturity spectrum) and monetary aggregates (both narrow and broader measures). In addition, we estimate both the full sample and the changing correlations (by means of a recursive estimation) between these cyclical factors, which will allow us analyse the eventual changing dynamics of the relationships between those variables. Several previous papers provide empirical evidence to support the changing regimes hypothesis in monetary models (e.g. Stock & Watson, 2003a; Primiceri, 2005; Sims & Zha, 2006). Two critical episodes of the US monetary policy history have been followed by discretionary policy responses by the Fed: the early years of Volker's mandate and the recent GFC. Volker's monetary policy gave rise to a new monetary regime which set the basis for the Great Moderation years. The second episode is being currently under discussion, as so the transition towards a more stable monetary policy strategy. In this context, we propose the adoption of a core information set as a reference for framing monetary policy decisions with a focus on price and monetary stability on long-term basis. As explained in the paper, this core information set shows a consistent relation between monetary growth broadly defined and inflation, defined as goods, services but also assets inflation; in this sense this core information could be interpreted as the provision of a more stable nominal anchor for the central bank.

The rest of the paper is structured as follows. In Section 2 we present the econometric model employed to estimate the cyclical common factors and to calculate the recursive correlations between them. In Section 3 common factor models and the corresponding full sample and recursive correlations are estimated and analysed. In Section 4, we focus on the last cyclical wave since 2001, a period in which asset prices during output expansion and discretionary measures (QE) in the recession have highly conditioned and dominated monetary policy decisions. The paper finishes with some concluding remarks and policy recommendations.

2. Cyclical common factor model and recursive correlations

Common factor models have reached a widespread use to summarize information from large datasets (for a recent a survey, see Barhoumi *et al.*, 2012) mainly to obtain synthetic indexes and for forecasting purposes. Less often this methodology has been employed for historical or structural analysis (e.g. Cendejas *et al.*, 2014ab, 2016; Cendejas & Font, 2015). Of the different approaches and estimation methods used, ours is based on the unobserved component model with a cyclical common factor proposed by Stock and Watson (1989, 1991), though with some distinctive modifications. The multivariate common factor model employed here embeds univariate Integrated Random Walk (IRW) models[5] for the observed series by linking them by means of a cyclical common factor, placing this common factor in the unobserved acceleration component of the IRW (Stock and Watson do it in the first log-difference of the series).

Consequently, each of the series (which are expressed in logarithms) follows the equation

$$y_{i,t} = \mu_{i,t} + \varepsilon_{i,t} \tag{1a}$$

where $\mu_{i,t}$ is a non-stationary trend or level component, $\varepsilon_{i,t} \sim NID(0,\sigma^2_{\varepsilon_i})$ and is uncorrelated across i 's in all leads and lags. The trend is supposed to change with $g_{i,t-1}$

$$\mu_{i,t} = \mu_{i,t-1} + g_{i,t-1} \tag{1b}$$

where $g_{i,t-1}$ is the underlying growth rate of $y_{i,t}$. The underlying growth component is assumed to follow

$$g_{i,t} = g_{i,t-1} + \gamma_i c_{t-1} + c_{i,t-1} \tag{1c}$$

Equation (1c) implies that changes in $g_{i,t}$, $\Delta g_{i,t}$, are the sum of a cyclical common component (the cyclical common factor), c_t, shared by the other series in the model, and an idiosyncratic or specific component, $c_{i,t}$. The parameter γ_i is the factor loading, a scale factor that amplifies or reduces c_t if positive (if negative, the variable would be countercyclical). Both cyclical components, c_t and $c_{i,t}$, are assumed to be white noise processes, so that

$$c_t = \eta_t \tag{1d}$$

$$c_{i,t} = \eta_{i,t} \tag{1e}$$

[5] Young (1984), Harvey (1989) and Kitagawa and Gersch (1996).

with $\eta_t \sim NID(0,1)$, $\eta_{i,t} \sim NID(0,\sigma^2_{\eta_i})$, mutually uncorrelated and with respect to $\varepsilon_{i,t}$ in all leads and lags. The variance of η_t is normalized to unity to allow the identification of the model.

The sign of the growth $g_{i,t}$ indicates the phase of the cycle, either expansionary or recessive under a classical business cycle notion. By incorporating cyclical components in $\Delta g_{i,t}$, we also consider both falls and upturns of the growth rate, that is, $\Delta g_{i,t}$ could be considered as an *acceleration component*. This component is equivalent in the frequency domain to the so-called growth cycle (that is, upturns and downturns in relation to a trend) usually estimated by applying the Hodrick-Prescott (HP) filter. In this respect, the HP filter is the optimal filter when the trend follows an IRW model (King and Rebelo, 1993), so, in our case, $\Delta g_{i,t}$ corresponds to the HP cycle as a deviation in relation to a trend, but we estimate, and thus not impose,[6] the smoothing parameter $\lambda_i = \dfrac{\sigma^2_{\varepsilon_i}}{\sigma^2_{\eta_i}}$. The equivalence between $\Delta g_{i,t}$ and the HP filter in the frequency domain given λ_i is shown in Cendejas *et al*. (2016).

The state space form of the model (1a) to (1e) allows for the variances, $\sigma^2_{\varepsilon_i}$ and $\sigma^2_{\eta_i}$, and the factor loadings, γ_i, to be estimated by maximum likelihood by using the Kalman filter (Harvey, 1989; Durbin and Koopman, 2001). By means of the filtering and smoothing algorithms, we can obtain the predicted components (as conditioned by the information available up to $t-1$), the filtered components (as conditioned by the information available up to t) and the smoothed components (using the full sample). For post-sample or historical analysis, the smoothed components are more appropriate. As indicated above, these components are the trends, $\hat{\mu}_{i,t}$, the underlying growth rates, $\hat{g}_{i,t}$, and the cyclical components, both the common and the specific component, $\hat{c}_t$ and $\hat{c}_{i,t}$, respectively.

Once the cyclical common factors have been estimated for the groups of series considered, we are interested in analysing the recursive correlations, $\rho_t(\hat{c}^j_t, \hat{c}^k_s)$, denoting by $\hat{c}^j_t$ the –

[6]When imposing the smoothing parameter, the HP cycle, $c^{HP}_{i,t} = y_{i,t} - \mu^{HP}_{i,t}$, may distort the true cyclical content of the observed series (see among others, Harvey & Jaeger, 1993).

standardized-[7] cyclical common factor of the *jth* group of variables. These can be modelled according to the following state space representation. The observation equation is

$$\hat{c}_t^j = \rho_t(\hat{c}_t^j, \hat{c}_s^k)\hat{c}_s^k + \nu_t \tag{2a}$$

and the transition equation

$$\rho_t(\hat{c}_t^j, \hat{c}_s^k) = \delta(\hat{c}_t^j, \hat{c}_s^k) + \phi\rho_{t-1}(\hat{c}_{t-1}^j, \hat{c}_{s-1}^k) + \xi_t \tag{2b}$$

where the recursive correlation is assumed to follow a stationary autoregressive model of order 1 with an intercept $\delta(\hat{c}_t^j, \hat{c}_s^k)$. The terms ν_t and ξ_t are white noise processes mutually uncorrelated in all leads and lags. Note that the full sample correlation between cyclical factors according (2b) is $\bar{\rho}(\hat{c}_t^j, \hat{c}_s^k) = \dfrac{\delta(\hat{c}_t^j, \hat{c}_s^k)}{1-\phi}$. The recursive lagged or lead correlations are estimated by merely changing properly the sub index s in $\hat{c}_s^k$.

3. Business cycle, inflation and the monetary policy (1960-2014)

Inflation dynamics along the business cycle has played a key role in the framing of monetary policy decisions. Even more, the different weight given by the Fed to inflation along the period of analysis (1960-2014) allows us to assess the different monetary policy bias of the Fed, and this will be shown in the following quantitative analysis. In particular, in this section we analyse the relationship between monetary policy and business cycle by means of unobserved component models. To obtain the cyclical components corresponding to the business cycle, inflation, interest rates and monetary aggregates, six common factor models have been estimated. The first one is obtained from the cyclical common factor of the GDP, the Industrial Production Index (IPI) and the (lagged) Dow Jones stock index. The second common factor model will synthesize the evolution of prices of goods and services along the period, and is estimated by using the Consumer Price Index (CPI), the Production Price Index (PPI) and the crude oil price (spot West Texas Intermediate). For the interest rates, we have estimated a short term interest rate common factor obtained from the Federal Funds (FF) and the 3-month Treasury Bill (TB) rates, and an interest rate common factor estimated by using a set of interest rates of different maturities: the two referred above and the 1-year, 3-year, 5-year and 10-year Treasury Constant Maturity (TCM) rates. The fifth cyclical common factor is obtained from the

[7] Because standardization is applied for the full sample, $\rho_t(\hat{c}_t^j, \hat{c}_s^k)$ might occasionally surpassed the (-1,1) interval.

monetary aggregates M1, M2 and M3.[8] The sixth adds the Monetary Base (MB) to this model. The figures corresponding to the annual growth rates of these variables are represented in Figures 1 and 3, except for the interest rates, which are measured in levels.[9] The six cyclical common factors corresponding to the business cycle, prices, interest rates (both short term and the entire set of interest rates) and monetary aggregates (without and with the MB) are denoted hereafter as c_t^{bc}, c_t^{pr}, $c_t^{\text{st\_int}}$, c_t^{int}, c_t^{m} and c_t^{m*}, respectively.

The results of the estimate of these common factor models are detailed in Table 1, where the reduced form of model (1) has been employed. For the interest rates factor the cyclical components are supposed to affect their variations, so equation (1c) becomes $g_{i,t} = \gamma_i c_{t-1} + c_{i,t-1}$; additionally the original series have not been log transformed. Consequently, the common factors $c_t^{\text{st\_int}}$ and c_t^{int} basically show interest rate variations. The other cyclical factors c_t^{bc}, c_t^{pr}, c_t^{m} and c_t^{m*}, as indicated, represent accelerations, i.e., variations of the respective underlying growth $\Delta g_{i,t}$. Consequently, c_t^{pr} represents inflationary (if positive) or disinflationary (if negative) shocks in the inflation of goods and services. In all the six models, the factor loadings are statistically significant, so the factors correctly synthetize the cyclical information in the corresponding variables. The figures of the cyclical common factors and their mean levels in expansions and recessions (both standardized) are included in Figure 2.

Starting with the business cycle common factor, it basically coincides with that of the GDP ($\sigma_{\eta 1}^2 = 0$) except for the observation noise $\varepsilon_{1,t}$. The greater amplitude corresponds to the stock index, which is something expected as asset prices are more volatile than real GDP. According to the significativity of the factor loading of the lagged Dow Jones stock index in Model 1.1, it may well be accepted its forecasting ability as regards the business cycle[10].

[8] On March 23, 2006, the Board of Governors of the Federal Reserve System ceased publication of the M3 monetary aggregate and its components (http://www.federalreserve.gov/releases/h6/discm3.htm). From 2006Q1 until 2014Q4, we have used data from Shadow Government Statistics, to whom we are grateful. We have verified that the common factor extracted only from M1 and M2 is practically identical to that obtained from M1, M2 and M3.

[9] The shaded areas correspond to the recession periods according the NBER: 1960Q2-1961Q1, 1969Q4-1970Q4, 1973Q4-1975Q1, 1980Q1-1980Q3, 1981Q3-1982Q4, 1990Q3-1991Q1, 2001Q1-2001Q4, 2007Q4-2009Q2 (http://www.nber.org/cycles.html).

[10] This coincides with a number of studies, for example, those cited in Stock and Watson (2003b) and the empirical study included therein, in which, however, the forecasting ability of asset prices (also on inflation) results unstable across countries and periods.

The corresponding plot of c_t^{bc} in Figure 2.1 shows a lower volatility in the business cycle from 1984. The negative shocks affecting the economy are clearly identified by means of the greater mean magnitudes corresponding to the 1980Q1-1980Q3, 1990Q3-1991Q1 and 2007Q4-2009Q2 recessive episodes. Regarding expansions, the more important positive shocks (in mean) took place in the short expansions of 1980Q4-1981Q2, in 1975Q2-1979Q4 and from 2009Q3 to the end of the sample. The reduction in volatility during the Great Moderation years received much attention in the pre-Great Recession literature: McConnell and Pérez-Quirós (2000), apart from testing the date of such a break in volatility (1984Q1), attribute it to a reduction in the volatility of durable goods production, which was in turn a consequence of improved inventory management. Kim and Nelson (1999) coincide in the date and also find a narrowing of the gap between growth rates during recessions and expansions. Chauvet and Potter (2001) extend the set of variables where a reduction of volatility is detected at that date. Kim *et al.* (2004) find this reduction in many broad production sectors and also in the persistence and conditional volatility of inflation that occurred over a similar time frame as the fall in the volatility in real GDP, which would be an outcome resulting from an improved monetary policy performance under Volcker and Greenspan's mandates. Stock and Watson (2003a) provide evidence on the quantitative importance of various explanations for the Great Moderation: the reduction in volatility is attributable to a combination of improved policy but most importantly, 'good luck' or one-off events such as productivity and commodity price shocks and reductions in the volatility of structural shocks.

Figure 1. US annual growth rates of the variables considered, except for the interest rates (in levels). Period: 1960Q1-2014Q4.

Figure 1.1. Annual growth rates of GDP, IPI and lagged Dow Jones index

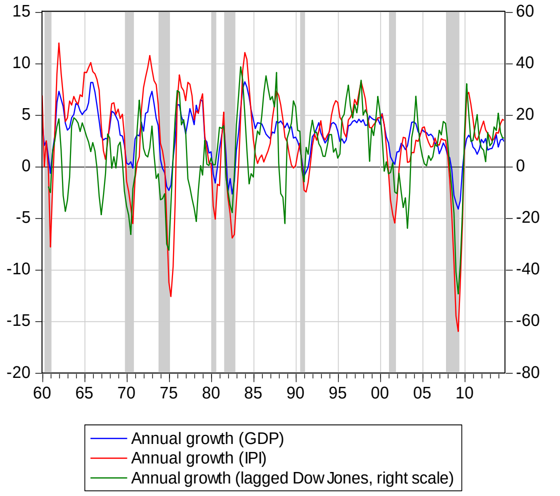


Figure 1.2. Inflation rates (CPI, GDP deflator)

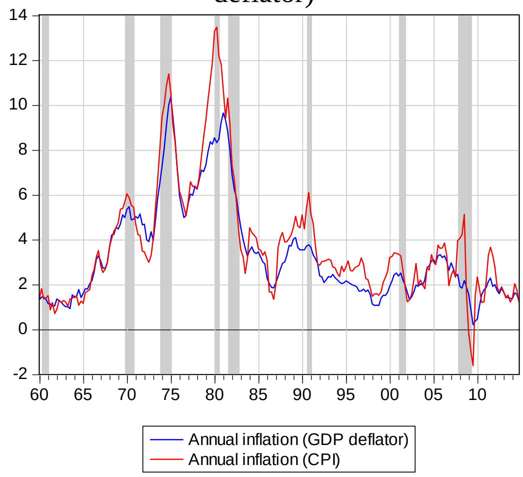


Figure 1.3. Inflation rates (PPI, Oil price)

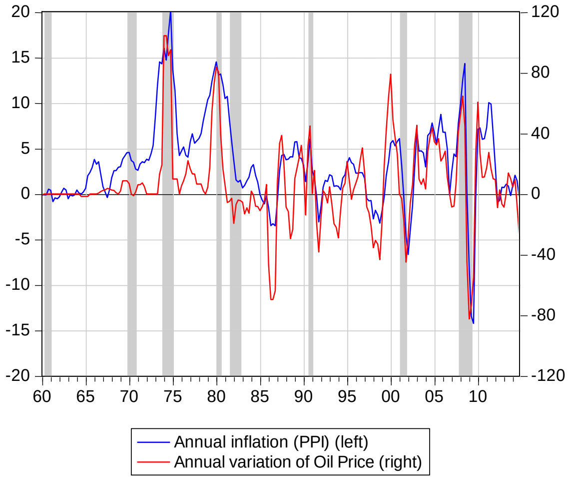


Figure 1.4. Interest rates (Fed Funds, 3m TB)

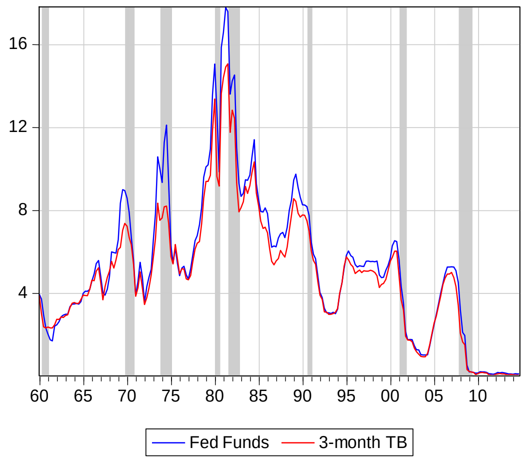


Figure 1.5. Interest rates (1y, 3y, 5y, 10y TCM)

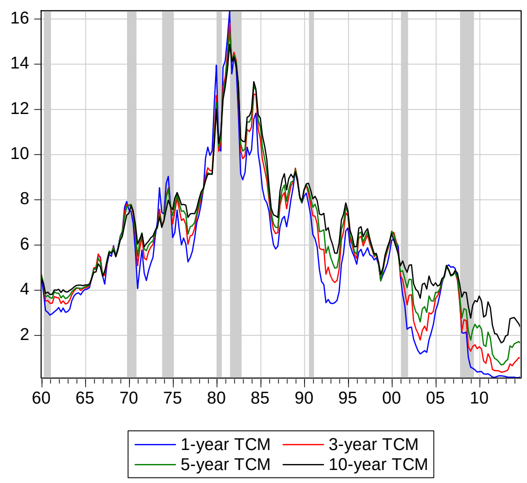


Figure 1.6. Annual growth rates of M1, M2 and M3

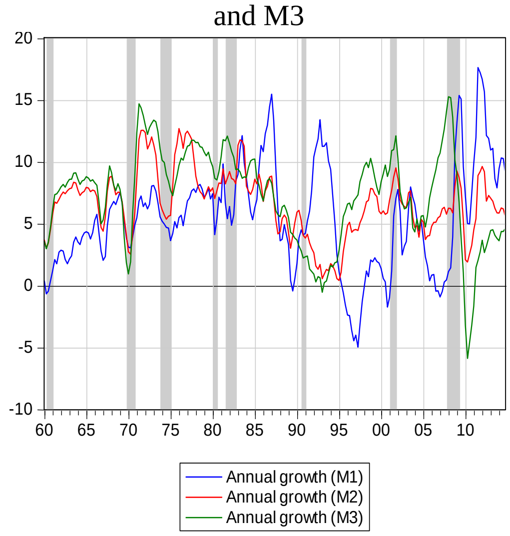


Table 1. Common factor model (1) for c_t^{bc} , c_t^{pr} , $c_t^{\text{st\_int}}$, c_t^{int} , c_t^{m} and c_t^{m*} . Period: 1960Q1-2014Q4.

$$\textbf{Model 1.1}: \; c_t^{bc}$$

$$\left\{\begin{array}{llll}
\Delta\log\text{GDP}_t = g_{1,t-1} + \Delta\varepsilon_{1,t} & \sigma^2_{\varepsilon 1} = \underset{(0.0156)}{0.1074} & \Delta g_{1,t} = \underset{(0.0412)}{0.5681} c^{bc}_{t-1} + \eta_{1,t} & \sigma^2_{\eta 1} = \underset{(0.0)}{0.0} \\
\Delta\log\text{IPI}_t = g_{2,t-1} + \Delta\varepsilon_{2,t} & \sigma^2_{\varepsilon 2} = \underset{(0.0316)}{0.0134} & \Delta g_{2,t} = \underset{(0.1005)}{1.2415} c^{bc}_{t-1} + \eta_{2,t} & \sigma^2_{\eta 2} = \underset{(0.0774)}{0.3135} \\
\Delta\log\text{DowJones}_{t-1} = g_{3,t-1} + \Delta\varepsilon_{3,t} & \sigma^2_{\varepsilon 3} = \underset{(2.1623)}{12.7045} & \Delta g_{3,t} = \underset{(0.4209)}{2.5764} c^{bc}_{t-1} + \eta_{3,t} & \sigma^2_{\eta 3} = \underset{(2.4125)}{8.4466} \\
c^{bc}_t = \eta_t & \sigma^2_{\eta} = 1 & &
\end{array}\right.$$

$$\textbf{Model 1.2}: \; c_t^{pr}$$

$$\left\{\begin{array}{llll}
\Delta\log\text{Deflator}_t = g_{1,t-1} + \Delta\varepsilon_{1,t} & \sigma^2_{\varepsilon 1} = \underset{(0.0020)}{0.0079} & \Delta g_{1,t} = \underset{(0.0197)}{0.0753} c^{pr}_{t-1} + \eta_{1,t} & \sigma^2_{\eta 1} = \underset{(0.0061)}{0.0272} \\
\Delta\log\text{CPI}_t = g_{2,t-1} + \Delta\varepsilon_{2,t} & \sigma^2_{\varepsilon 2} = \underset{(0.0040)}{0.0182} & \Delta g_{2,t} = \underset{(0.0302)}{0.4027} c^{pr}_{t-1} + \eta_{2,t} & \sigma^2_{\eta 2} = \underset{(0.0100)}{0.0110} \\
\Delta\log\text{PPI}_t = g_{3,t-1} + \Delta\varepsilon_{3,t} & \sigma^2_{\varepsilon 3} = \underset{(0.0659)}{0.1671} & \Delta g_{3,t} = \underset{(0.1128)}{1.4892} c^{pr}_{t-1} + \eta_{3,t} & \sigma^2_{\eta 3} = \underset{(0.1679)}{0.2619} \\
\Delta\log\text{Oil_pr}_t = g_{4,t-1} + \Delta\varepsilon_{4,t} & \sigma^2_{\varepsilon 4} = \underset{(7.2349)}{28.2288} & \Delta g_{4,t} = \underset{(0.9513)}{9.4490} c^{pr}_{t-1} + \eta_{4,t} & \sigma^2_{\eta 4} = \underset{(12.4156)}{30.5201} \\
c^{pr}_t = \eta_t & \sigma^2_{\eta} = 1 & &
\end{array}\right.$$

$$\textbf{Model 1.3}: \; c_t^{\text{st\_int}}$$

$$\left\{\begin{array}{llll}
\Delta\text{Fed_funds}_t = g_{1,t-1} + \Delta\varepsilon_{1,t} & \sigma^2_{\varepsilon 1} = \underset{(0.0205)}{0.0062} & g_{1,t} = \underset{(0.1242)}{0.8832} c^{\text{st_int}}_{t-1} + \eta_{1,t} & \sigma^2_{\eta 1} = \underset{(0.2026)}{0.0630} \\
\Delta\text{3m_int}_t = g_{2,t-1} + \Delta\varepsilon_{2,t} & \sigma^2_{\varepsilon 2} = \underset{(0.0134)}{0.0218} & g_{2,t} = \underset{(0.0983)}{0.7048} c^{\text{st_int}}_{t-1} + \eta_{2,t} & \sigma^2_{\eta 2} = \underset{(0.1287)}{0.0094} \\
c^{\text{st_int}}_t = \eta_t & \sigma^2_{\eta} = 1 & &
\end{array}\right.$$

$$\textbf{Model 1.4}: \; c_t^{\text{int}}$$

$$\left\{\begin{array}{llll}
\Delta\text{Fed_funds}_t = g_{1,t-1} + \Delta\varepsilon_{1,t} & \sigma^2_{\varepsilon 1} = \underset{(0.0)}{0.0} & g_{1,t} = \underset{(0.0542)}{0.6492} c^{\text{int}}_{t-1} + \eta_{1,t} & \sigma^2_{\eta 1} = \underset{(0.0413)}{0.4297} \\
\Delta\text{3m_int}_t = g_{2,t-1} + \Delta\varepsilon_{2,t} & \sigma^2_{\varepsilon 2} = \underset{(0.0)}{0.0} & g_{2,t} = \underset{(0.0408)}{0.5903} c^{\text{int}}_{t-1} + \eta_{2,t} & \sigma^2_{\eta 2} = \underset{(0.0181)}{0.1886} \\
\Delta\text{1y_int}_t = g_{3,t-1} + \Delta\varepsilon_{3,t} & \sigma^2_{\varepsilon 3} = \underset{(0.0)}{0.0} & g_{3,t} = \underset{(0.0375)}{0.6967} c^{\text{int}}_{t-1} + \eta_{3,t} & \sigma^2_{\eta 3} = \underset{(0.0060)}{0.0625} \\
\Delta\text{3y_int}_t = g_{4,t-1} + \Delta\varepsilon_{4,t} & \sigma^2_{\varepsilon 4} = \underset{(0.0)}{0.0} & g_{4,t} = \underset{(0.0300)}{0.6227} c^{\text{int}}_{t-1} + \eta_{4,t} & \sigma^2_{\eta 4} = \underset{(0.0)}{0.0} \\
\Delta\text{5y_int}_t = g_{5,t-1} + \Delta\varepsilon_{5,t} & \sigma^2_{\varepsilon 5} = \underset{(0.0)}{0.0} & g_{5,t} = \underset{(0.0274)}{0.5537} c^{\text{int}}_{t-1} + \eta_{5,t} & \sigma^2_{\eta 5} = \underset{(0.0009)}{0.0095} \\
\Delta\text{10y_int}_t = g_{6,t-1} + \Delta\varepsilon_{6,t} & \sigma^2_{\varepsilon 6} = \underset{(0.0)}{0.0} & g_{6,t} = \underset{(0.0244)}{0.4450} c^{\text{int}}_{t-1} + \eta_{6,t} & \sigma^2_{\eta 6} = \underset{(0.0029)}{0.0305} \\
c^{\text{int}}_t = \eta_t & \sigma^2_{\eta} = 1 & &
\end{array}\right.$$

Model 1.5 : c_t^m

$$\begin{cases} \Delta \log \mathrm{M1}_t = g_{1,t-1} + \Delta\varepsilon_{1,t} & \sigma^2_{\varepsilon 1} = \underset{(0.0194)}{0.0893} & \Delta g_{1,t} = \underset{(0.0644)}{0.6384} c^m_{t-1} + \eta_{1,t} & \sigma^2_{\eta 1} = \underset{(0.0541)}{0.2980} \\ \Delta \log \mathrm{M2}_t = g_{2,t-1} + \Delta\varepsilon_{2,t} & \sigma^2_{\varepsilon 2} = \underset{(0.0066)}{0.0137} & \Delta g_{2,t} = \underset{(0.0442)}{0.6324} c^m_{t-1} + \eta_{2,t} & \sigma^2_{\eta 2} = \underset{(0.0)}{0.0} \\ \Delta \log \mathrm{M3}_t = g_{3,t-1} + \Delta\varepsilon_{3,t} & \sigma^2_{\varepsilon 3} = \underset{(0.0058)}{0.0151} & \Delta g_{3,t} = \underset{(0.0405)}{0.3779} c^m_{t-1} + \eta_{3,t} & \sigma^2_{\eta 3} = \underset{(0.0285)}{0.1782} \\ c^m_t = \eta_t & \sigma^2_\eta = 1 & & \end{cases}$$

Model 1.6 : c_t^{m*} (with MB_t)

$$\begin{cases} \Delta \log \mathrm{MB}_t = g_{1,t-1} + \Delta\varepsilon_{1,t} & \sigma^2_{\varepsilon 1} = \underset{(0.6668}{2.0029} & \Delta g_{1,t} = \underset{(0.2749)}{0.8901} c^{m*}_{t-1} + \eta_{1,t} & \sigma^2_{\eta 1} = \underset{(2.0080)}{7.3913} \\ \Delta \log \mathrm{M1}_t = g_{2,t-1} + \Delta\varepsilon_{2,t} & \sigma^2_{\varepsilon 2} = \underset{(0.0192)}{0.0875} & \Delta g_{2,t} = \underset{(0.0643}{0.6423} c^{m*}_{t-1} + \eta_{2,t} & \sigma^2_{\eta 2} = \underset{(0.0540)}{0.2977} \\ \Delta \log \mathrm{M2}_t = g_{3,t-1} + \Delta\varepsilon_{3,t} & \sigma^2_{\varepsilon 3} = \underset{(0.0065)}{0.0143} & \Delta g_{3,t} = \underset{(0.0435)}{0.6294} c^{m*}_{t-1} + \eta_{3,t} & \sigma^2_{\eta 3} = \underset{(0.0)}{0.0} \\ \Delta \log \mathrm{M3}_t = g_{4,t-1} + \Delta\varepsilon_{4,t} & \sigma^2_{\varepsilon 4} = \underset{(0.0059)}{0.0153} & \Delta g_{4,t} = \underset{(0.0405)}{0.3754} c^{m*}_{t-1} + \eta_{4,t} & \sigma^2_{\eta 4} = \underset{(0.0287)}{0.1789} \\ c^{m*}_t = \eta_t & \sigma^2_\eta = 1 & & \end{cases}$$

Concerning prices, it can be noted from the graphs in Figure 1 that the shocks affecting oil prices pass on to the PPI, the CPI, the GDP deflator, and to the real GDP (see Hamilton, 2003). Significant increases in oil prices occurred in the recessions of the middle of the 1970’s, the beginning of the 1980’s and 1990’s, and prior to the recessions of the 2000’s (1999-2000 and in 2007-08). Either its triggering or accompanying role during recessions is evident. But it is important to note (see Figure 1.3) the difference between the temporary oil price shocks prevailing before 2000 and the persistent positive shocks of the period 2001-2008 caused by a worldwide expansionary process. Furthermore, the upward trend of the CPI and the GDP deflator until 1980, and the downward trend from this year, is not so evident either in the oil price or in the PPI. These facts points out the important difference between a price shock and an inflationary (or disinflationary) trend. A sustained increase (or decrease) in inflation needs a sustained increase (or decrease) in money growth, so the final word on inflation corresponds to the monetary policy response (Bernanke *et al.*, 1997).

Figure 2. US cyclical common factors (blue line) and their mean levels (red lines) in expansions and recessions, both standardized. Period: 1960Q1-2014Q4.

Figure 2.1. Business cycle cf, c_t^{bc}

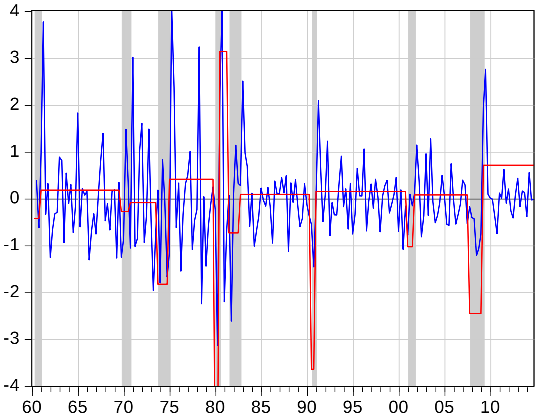


Figure 2.2. Prices cf, c_t^{pr}

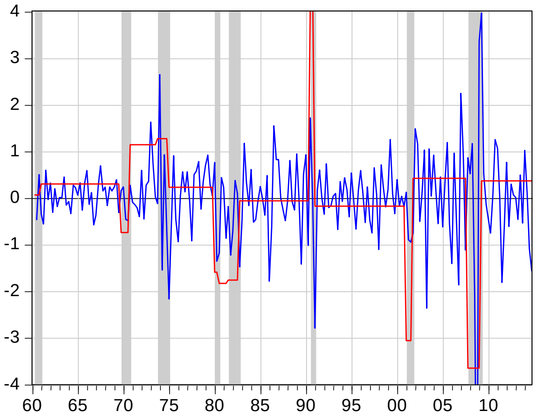


Figure 2.3. Short term interest rate cf, $c_t^{\text{st\_int}}$

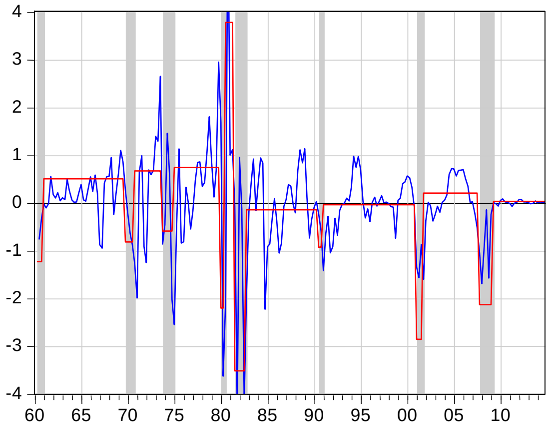


Figure 2.4. Interest rates cf, c_t^{int}

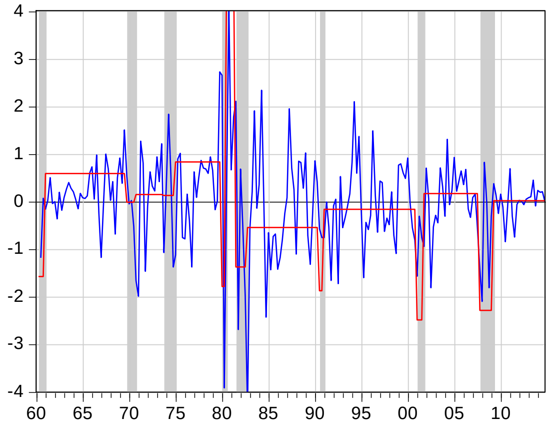


Figure 2.5. Monetary aggregates cf, c_t^{m}

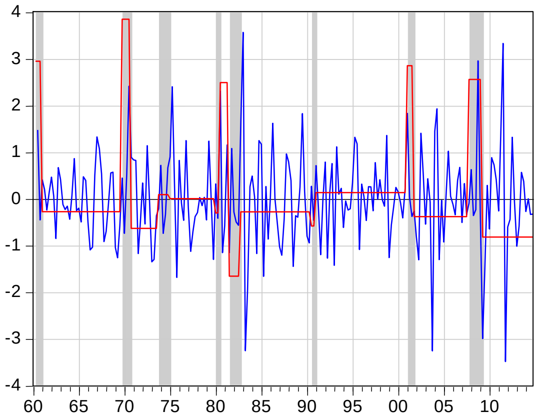


Figure 2.2 corresponding to the prices' factor (c_t^{pr}) shows the prevalence of inflationary shocks in the expansions of output in 1961-1969, 1971-1975, 2002-2007 and from 2009Q3 to the end of the sample; as well as the importance of the disinflationary period from 1980Q1 to 1982Q4 (the beginning of Volcker's mandate) that changed the sign of the trend in inflation. After a drastic reduction in CPI inflation, from 1983 to 2000 a slight disinflation trend prevailed (a negative mean in c_t^{pr}) despite the occurrence of some increases (shocks) in oil prices (see Figure 1.3) and, even more important, disinflation was accompanied by two prolonged expansionary phases of the business cycle (with the exception of the 1990Q3-1991Q1 recession). So there have been several so-called 'good' or 'benign' disinflation (Selgin, 1997; Bordo *et al.*, 2004) periods in the US since the mid-1980s coinciding with the Great Moderation years until 2002. From this year, inflation gathers momentum (again the mean c_t^{pr} is positive) until the outbreak of the Great Recession. In relation with Greenspan's mandate, Romer and Romer (2004) point out that since the mid-1990s, the surprising behaviour of inflation appeared to have led Greenspan and some other members of the FOMC to change their views regarding the determinants of inflation. Greenspan argued that the economy had become much more competitive which incentivized firms to cut down costs and to operate in a more competitive low inflation environment. Thus, the assumed qualitative change in inflation behaviour led to a more lax policy view against inflation from the mid-1990s, which supports the argument that the Fed provided plenty of liquidity to foster the US economic growth in the early 2000s.

The existence of either pro or countercyclical inflation along this period can be assessed by the analysis of the recursive correlation between the business (c_t^{bc}) and the prices' factors (c_t^{pr}) (see Figure 4.1). Procyclical inflation would be related to the predominance of demand shocks, and countercyclical inflation to supply driven shocks. Full sample correlation (see Figure 9a in Table A.1 of the Appendix) shows that both the lagged ($\rho(c_{t-1}^{\mathrm{bc}}, c_t^{pr}) > 0$) and the contemporary correlation ($\rho(c_t^{\mathrm{bc}}, c_t^{pr}) > 0$) are just slightly positive. This small correlation can be explained by the combined presence along such a long period of time of demand and supply side driven shocks although with a predominance of the former.[11] The adoption of an implicit inflation target by the Fed in the last decades during both expansions and recessions helps explain the dominance of the positive relation between inflation variations and changes in economic activity along the sample; in fact, within an implicit inflation target, even in times of output expansion driven by productivity growth the Fed prevented inflation from falling below the target by conducting a more expansionary monetary policy to offset any deflationary pressure. However,

[11] As shown by the recursive correlation in Figure 4.1.

there were several periods of negative recursive correlation driven by either negative (such as the oil crises in the mid-1970s) or the mentioned positive supply shocks experienced along the 1990s and around 2005. The greater mean of the positive correlations corresponds to the recession of 2007Q4-2009Q2 and the expansions of the 1980's and the 2000's.

Concerning short-term interest rates, the Fed Funds and 3-month Treasury Bills rates move jointly across the sample (see Figure 1.4). But the FF rate exceeds the 3-month TB rate mainly during recessive periods (in the 1970s and in the early 1980s) but also, even though to a lesser extent, in expansionary periods (1983 to 1990, 1995 to 2001 and 2006 to 2009). This may be indicative of higher rates of inflation, both recorded and expected, and thus of rises in the FF rates. The interest rates common factor model estimated by using the FF and the 3-month TB will help us summarize the monetary policy responses of the Fed in this period. Although a more persistent behaviour can be observed since around 1984 (see Figure 2.3), $c_t^{\text{st\_int}}$ is yet modelled for the full sample as a white noise process due to the observed random its apparent changes before 1984this year. This higher persistence in interest rates behaviour is the consequence of the adoption of a smoothing policy on FF rates by the Fed (e.g. Clarida *et al.*, 2000) consisting of the gradual approach to the desired level of interest rates. The greater negative sign of $c_t^{\text{st\_int}}$ (reductions in the Fed's short-term interest rates) corresponds mainly to recessive periods, which would be the expected reaction of the Fed in the face of a contractionary output phase and the absence of inflationary risks. However, the negative sign of $c_t^{\text{st\_int}}$ also applies to some expansionary periods as the year 1967, from 1984 to 1987, from 1989 to 1993, in 1995, 1998 and in 2002-03. Some of these reductions could be considered part of the so-called 'Greenspan's put' (Hall, 2011) that would have pursued to avoid the recessive effects of some important negative shocks affecting stock markets at the cost of creating moral hazard problems and market overvaluation.

For the full set of interest rates, a common factor is also identified. All the factor loadings are statistically significant with a greater value (i.e. greater amplitude) in the 1-year TCM rate. Two interest rate variations (3-year and 5-year TCM) are practically assimilated to the common factor c_t^{int} due to the zero value of their estimated variances. The comparison of $c_t^{\text{st\_int}}$ with c_t^{int} shows the greater volatility of the short-term interest rates factor ($c_t^{\text{st\_int}}$) in respect to the full set interest rate factor (c_t^{int}) before 1984 and the opposite behaviour from this year onwards (for annual differences, Watson, 1999). The more persistent behaviour of the FF from 1984 makes changes in the short-term interest rates to become more permanent by creating the expectation of a constant policy in the near future. In turn, this makes the influence of short term interest rates on long term ones more powerful, as well as a more effective monetary policy (Goodfriend, 1991).

Concerning monetary aggregates (Figure 1.6), it is worth noting the sudden increases observed in M1 under financial instability episodes or whenever there has been high uncertainty and volatility in the market: the first half of the 1990s, the dot.com bust, the terrorist attacks in Washington D.C. and New York in 2001, and the years of the GFC. Additionally, it can be seen that the annual growth rates of M2 and M3 run almost in parallel except for the second half of the nineties and from 2005 onwards. Since the 1990s the behaviour of Money Market Mutual Funds (MMMF), included in the definition of M3 but not in M2, mainly explains the discrepancies between these two broad monetary aggregates. The increase in MMMF since 2004 until the outbreak of the GFC is particularly significant, as well as its collapse since 2008, resulting from the tightening of bank regulation in the midst of the last crisis, and thus the much timid growth of M3 as compared with M2 in the U.S. in the last few years.[12] For the monetary aggregates, a cyclical common factor, c_t^{m}, is identified, which shows (Figure 2.5) positive monetary shocks coinciding or around all recessive periods, as well as the financial turmoil episodes listed above. A more profound insight on the dynamics of the monetary common factor is made below when analysing interest rate variations and their transmission to activity and prices through agents' portfolio adjustments.

The exceptional measures adopted by the Fed in the last seven years are reflected in the graphs contained in Figure 3, in particular the extraordinary increase in the monetary base (approximately fivefold from 2007 to 2014). In Figure 3.1 it is shown how the monetary base has even surpassed[13] M1 from the end of 2008 causing its multiplier to diminish quite notably (being even lower than 1), which evidences the activism of the Fed in the creation of high powered money, unmatched by the banks' willingness to expand liquid deposits. We show in Figure 3.2 the money multipliers computed as the ratio of the monetary aggregate over the monetary base ($\mathrm{mm}_i = \mathrm{M}_i / \mathrm{MB}$): all show the collapse of the banking sector balance sheet in 2008 and thus of bank deposits creation, which is much more notable as regards the multiplier of M3 and thus the less liquid deposits. Figure 3.2 shows a decreasing trend of the multiplier of M1 (mm_1) along the period, and the evolution in parallel of the multipliers of M2 and M3 (

[12] We want to thank Prof. Congdon for his comments on this question and for drawing our attention to the different evolution of these two monetary aggregates in the last two decades in the U.S.

[13] The extraordinary increase in banks reserves may well be explained by the Fed remuneration of the banks reserves, which in a financial crisis scenario increases the willingness of keeping the money in the Fed's vaults.

mm_2 and mm_3, respectively) with the exceptions of the 1995-2001 and 2005-2008 when mm_3 experiences an upward trend linked, as mentioned above, to changes in MMMF. This general run for liquidity in 2008 (manifested in an abnormal demand for cash balances) explains the initial collapse of the specific components of the broad monetary aggregates and clearly points out the need for the Fed to maintain the stability in the quantity of (broad) money at the time. When added the monetary base to the monetary aggregates factor (Model 1.6), no substantial changes occur in the estimated cyclical common factor for the monetary aggregates, and the successive QE rounds are clearly reflected in the estimated specific component of the monetary base ($c_{1,t} = \eta_{1,t}$, see Figure 3.6).

Analysis of the policy response correlations

The subsequent analysis is based both on full sample and recursive correlations[14] between the estimated cyclical common factors. The signs of full sample correlations (those statistically significant) are shown in Table 2 (see also Table A.1 in the Appendix). Obviously, the completed set of correlations is the result of indistinguishable both policy and private agents' decisions and capture an average pattern along the whole sample; however, a stylised and coherent explanation based on the monetary policy response to inflationary pressures can give reasonable account of these correlations[15]. The correlations have been grouped according to three stages in the making and evaluating monetary policy decisions: first, the monetary policy response to changes in inflation and output indicators; second, the effectiveness of the policy decisions on prices and the business cycle; and finally the reversing policy once effectiveness (or to put it differently, the targets of the central bank) has been reached.

[14] The estimation results of the models of the recursive correlations are available upon request. The recursive correlations not plotted in Figure 4 were constant, quite stable or did not add relevant information apart from the one already considered.

[15] According to a Taylor-type rule, monetary policy responses by means of interest rate variations are produced both with inflation deviations on target and with output gap variations. As seen, inflation and activity variations are positively correlated, so to give priority to inflation in reasoning does not lead to wrong conclusions.

Figure 3. US annual growth rates of the Monetary Base (MB) and several Monetary Aggregates (Mi), and money multipliers (mm_i). Period: 1960Q1-2014Q4.

Figure 3.1. Monetary base and M1 (billions of dollars). Period: 2007Q1-2014Q4

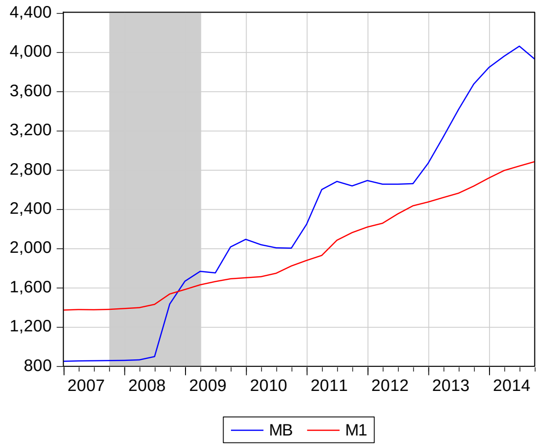


Figure 3.2. Money multipliers

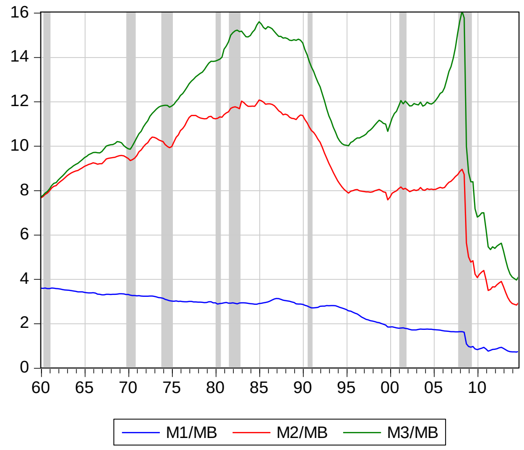


Figure 3.3. Annual growth rates of the MB and M1. Period: 1960Q1-2006Q4

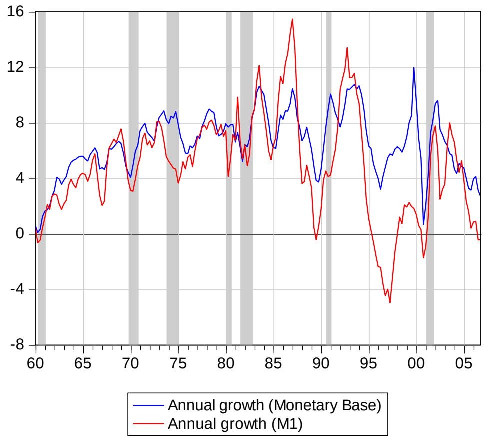


Figure 3.4. Annual growth rates of the MB, M2 and M3. Period: 1960Q1-2006Q4

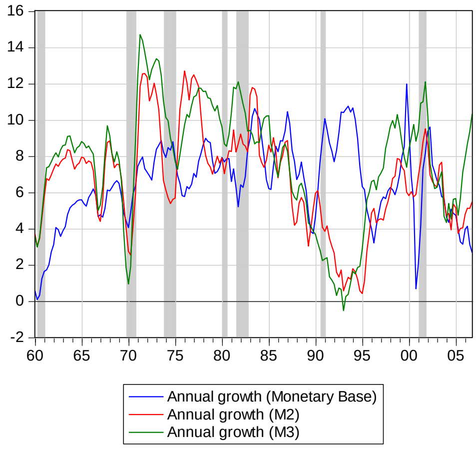


Figure 3.5. Annual growth rates of the MB, M1, M2 and M3. Period: 2007Q1-2014Q4

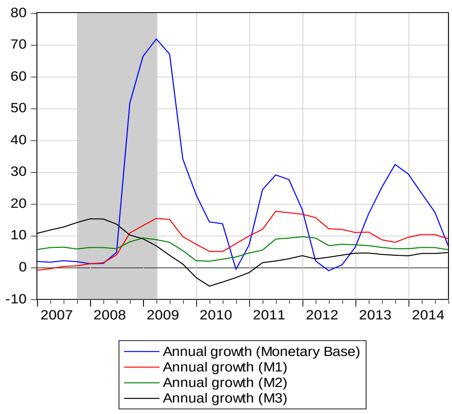


Figure 3.6. Specific component of the Monetary Base

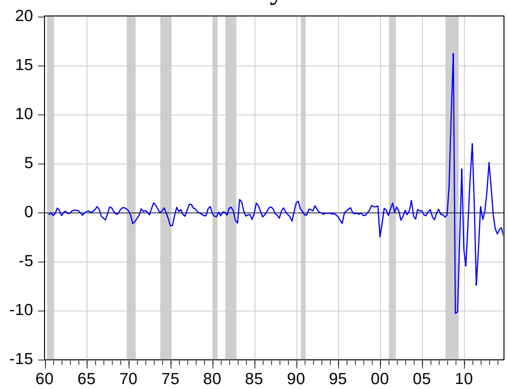


Table 2. Full sample cross correlations between cyclical common factors [(*)]

Policy response correlations	
Prices perspective $\rho(c_t^{\text{st\_int}}, c_t^{pr}) > 0$ (4a) $\rho(c_t^{\text{int}}, c_t^{pr}) > 0$ (6b) Portfolio adjustments $c_{t-k}^{\text{st\_int}} \to c_t^{m} : \rho(c_{t-1}^{\text{st\_int}}, c_t^{m}) < 0, \rho(c_t^{\text{st\_int}}, c_t^{m}) < 0$ (7b) $c_{t-k}^{\text{int}} \to c_t^{m} : \rho(c_{t-1}^{\text{int}}, c_t^{m}) < 0, \rho(c_t^{\text{int}}, c_t^{m}) < 0$ (8b) Prices perspective of portfolio adjustments $c_{t-k}^{pr} \to c_t^{m} : \rho(c_t^{m}, c_t^{pr}) < 0,\ \rho(c_t^{m}, c_{t-1}^{pr}) < 0$ (2b)	Business cycle perspective $c_{t-k}^{bc} \to c_t^{\text{st\_int}} : \rho(c_t^{\text{st\_int}}, c_t^{bc}) > 0, \rho(c_t^{\text{st\_int}}, c_{t-1}^{bc}) > 0$ (3b) $\rho(c_t^{\text{int}}, c_t^{bc}) > 0$ (5b) Monetary aggregates perspective $c_{t-k}^{bc} \to c_t^{m} : \rho(c_t^{m}, c_{t-1}^{bc}) < 0$ (1b)
Effectiveness correlations	
Prices perspective $c_{t-k}^{\text{int}} \to c_t^{pr} : \rho(c_{t-2}^{\text{int}}, c_t^{pr}) < 0$ (6a) Monetary aggregates perspective $c_{t-k}^{m} \to c_t^{pr} : \rho(c_{t-2}^{m}, c_t^{pr}) > 0$ (2a)	Business cycle perspective $c_{t-k}^{\text{st\_int}} \to c_t^{bc} : \rho(c_{t-2}^{\text{st\_int}}, c_t^{bc}) < 0,\ \rho(c_{t-1}^{\text{st\_int}}, c_t^{bc}) < 0$ (3a) $c_{t-k}^{\text{int}} \to c_t^{bc} : \rho(c_{t-2}^{\text{int}}, c_t^{bc}) < 0,\ \rho(c_{t-1}^{\text{int}}, c_t^{bc}) < 0$ (5a) Monetary aggregates perspective $c_{t-k}^{m} \to c_t^{bc} : \rho(c_{t-2}^{m}, c_t^{bc}) > 0,\ \rho(c_{t-1}^{m}, c_t^{bc}) > 0$ (1a)
Reversing policy correlations	
Portfolio adjustments $c_{t-k}^{\text{st\_int}} \to c_t^{m} : \rho(c_{t-3}^{\text{st\_int}}, c_t^{m}) > 0,\ \rho(c_{t-2}^{\text{st\_int}}, c_t^{m}) > 0$ (7a) $c_{t-k}^{\text{int}} \to c_t^{m} : \rho(c_{t-3}^{\text{int}}, c_t^{m}) > 0,\ \rho(c_{t-2}^{\text{int}}, c_t^{m}) > 0$ (8a) Prices perspective $c_{t-k}^{pr} \to c_t^{m} : \rho(c_t^{m}, c_{t-2}^{pr}) > 0$ (2c)	Business cycle perspective $c_{t-k}^{\mathrm{pr}} \to c_t^{bc} : \rho(c_{t-2}^{\mathrm{bc}}, c_t^{pr}) < 0, \rho(c_{t-3}^{\mathrm{bc}}, c_t^{pr}) < 0$ (9b)

[(*)] The numbers in brackets (1a, 1b, etc.) correspond to location in Table A.1 in the Appendix.

When inflation rises above the desired or expected level, the Fed rises the (target) interest rate (correlation 4a, Table 2 below), and eventually the banks or the public will anticipate to such a policy change by changing their inflation expectations and other long term interest rates which will reinforce the Fed's response (correlation 6b). And the contrary occurs when inflation falls below the desired or expected level. Increasing (decreasing) interest rates causes portfolio adjustments lasting two quarters, which consists of a decreasing (increasing) demand for cash balances (correlations in 7b and 8b) and the increase of the demand for alternative real and financial assets (see further analysis on it below). Given the correlation between inflation and interest rates, these portfolio adjustments cause a negative correlation between prices (inflation) and monetary aggregates (correlation 2b). Moreover, given that a positive correlation between inflation and the business cycle prevails along the sample, an improvement in the business cycle will be accompanied by inflationary pressures and thus higher interest rates (see the positive correlations in 3b and 5b), which also suggests the implicit running of a Taylor-type rule. Equation 1b reflects the correlation implied by the portfolio adjustments and the business cycle in the previous quarter whilst equation 3b offers the monetary aggregate perspective of this correlation; in a nutshell, am improvement in the business cycle would trigger at some point inflationary pressures and thus a raise in the policy instrument, short term interest rates, which results in a lower rate of growth of the monetary aggregates. Monetary policy achieves the intended goals in terms of inflation after two quarters.[16] This can be shown by the negative correlation estimated between lagged (two quarters) interest rates and prices in 6a, which can also be shown in 2a as monetary aggregates take two quarters to hit prices.

In line with the analysis of the Fed's monetary policy changes made in the Introduction, the analysis of the recursive correlations will help us assess the changes in the monetary policy bias of the Fed since 1960 onwards. As shown in Figure 4.2 for the correlation between short term interest rates and prices ($\rho_t(c_t^{st\_\text{int}}, c_t^{pr})$) , even though positively correlated all throughout the sample, Fed's short term interest rates changed differently to variations in inflation during different time periods. From 1960 until 1970, under the Breton Woods system short-term interest rates showed a quite stable reaction towards changes in inflation. From 1971 to 1975, a minor recursive correlation coincides with the quite significant inflationary shocks (see Figure 2.2) taking place after the breakdown of the fixed exchange rate system and the hit of the first oil price shock; this shows that short-term interest rate variations in this period were more accommodative to inflation as compared to the results obtained when using the full sample. In 1979, the adoption of a new monetary policy regime meant the use of a monetary aggregate and not interest rates as the main policy instrument of the Fed. This policy change well explains the reduction in the correlation between inflation and contemporary short-term interest rates from 1979 until 1983, which became an endogenous variable within that money-based monetary policy strategy. The success in reducing inflation in this period is shown in Figure 2.2 where disinflationary shocks prevail. Moreover, the effect of the successive oil shocks in the 1970s and in early 1980s is reflected in a much more abrupt reaction of short-term interest rates to much higher and more volatile inflation rates.

Since the end of a new oil price rise in the early 1990s until the dot.com crisis in 2001, the correlation between prices and short-term interest rates was stable in line with nearly steady and low inflation expectations and sustained economic growth for more than a decade, which

[16] This result is not in the line of other estimations of the time horizon for achieving the objectives of the Fed, which tends to be longer. Although before the GFC, see Angeloni *et al*. (2003).

reflects the stability of the so-called Great Moderation years. However, from 2002 to 2007 in spite of greater inflationary shocks (Figure 2.2) affecting the US economy, the recursive correlation between short interest rates and prices remained equal on average; which shows an insufficient reaction of the Fed to those inflationary pressures. As expected, with the outbreak of the last recession the reaction of the Fed's short-term interest rate to changes in inflation has been more active and much larger in view of a major negative demand shock affecting the economy, with extraordinary recessive and deflationary effects. However, this correlation (and thus the Fed's timely response to the crisis) is not evident in 2007 but in 2008, which implies a lag in the Fed's reaction to the signals already being sent by the markets since the summer of 2007. Once nominal short-term interest rates virtually reached the zero bound in 2009, the correlation between short term interest rates and prices has become very steady, being since then other extraordinary policy measures and not changes in FF interest rates the main drivers of the Fed's monetary policy response to the financial crisis.

When not only short term but also long term market interest rates are considered, the recursive correlation between interest rates and prices ($\rho_t(c_t^{\text{int}}, c_t^{pr})$, see Figure 4.3 below) coincides with the falls observed above between short term rates and prices in the early 1970s and 1980s (inflationary and disinflationary trends respectively). But a greater correlation is observed from 2001 onwards in line with the analysis made above on the bias of the Fed's policy in the post 2001 period. Higher inflationary expectations in the 2000's decade were reflected in higher market (long term) interest rates, which gives further evidence on the too loose monetary policy stance followed by the Fed from 2001 until the outbreak of the GFC. The fall in CPI prices as well as the expectation of deflation in 2008 and 2009 was followed by a fall in market interest rates in the midst of the crisis and thus by a high correlation between these two variables. Since 2010, the correlation remains in the levels before the GFC and may show a market expectation of continuity in the monetary policy response of the Fed to inflation.

In relation to the impact of changes in economic activity on the Fed's monetary policy since 1961, the recursive correlation between interest rates and the business cycle ($\rho_t(c_t^{\text{int}}, c_t^{bc})$) is positive throughout the sample (Figure 4.4), as expected. A notable fall in the early 1970s occurred though, showing again the change towards a more accommodative response of the Fed's interest rates to inflation; and again a hike in the early 1980s, when Volcker's contractionary policy took place. Since then the correlation between short term interest rates and the cycle ($\rho_t(c_t^{st\_\text{int}}, c_t^{pr})$) has remained positive and quite stable, which may indicate the quite stable weights given to inflation and output changes in the framing of the Fed's monetary policy and the pursuit of the 'dual mandate'. With the benefit of hindsight, this nearly constant pattern of response even when inflation revived from 2001 on may have been insufficient given the inflation developments observed in the years prior to the GFC.[17]

Effectiveness and reversing policy correlations

Monetary policy effectiveness on inflation is explained through the effects of monetary and interest rate changes on the business cycle in the short term. The significant negative correlations between interest rates (one and two quarters lagged) and the business cycle in correlations 3a and 5a (in Table 2) confirms it. In Figure 4.5 the recursive correlation between short term interest rates and the business cycle ($\rho_t(c_{t-2}^{st\_int}, c_t^{bc})$) allows us to point at the ineffectiveness of short term interest rate variations on activity in the early 1970s, during the brief economic expansion of 1980-81, and during the Great Financial Recession. Keeping interest rates steady or even the reverse of the interest rate variations by the Fed once the policy target has been achieved is coherent with the sign of the correlations between the two and three quarters lagged business cycle and contemporary prices shown in equation 9b. The positive correlation between one and two quarters lagged monetary aggregates and the business cycle in equation 1a runs in parallel with the positive correlation between monetary aggregates and inflation in equation 2a and the negative one between interest rates and prices in equation 6a. As regards the positive correlation between lagged monetary aggregates and the business cycle ($\rho_t(c_{t-1}^{m}, c_t^{bc})$, see Fig. 4.6 below), we can observe greater variability in the early 1970s and 1980s thus coinciding with the behaviour commented above on inflation and interest rates at that time and the application of the so-called 'practical monetarism' strategy in the early years of Volcker's regime, and finally a reduction in the correlation between monetary aggregates and the business cycle after the Great Financial Recession. As seen recently, the GFC was followed by a fivefold increase in the monetary base in the US, however not reflected in a major increase in other broader monetary aggregates. The effects of fostering money growth (the monetary base) to prevent GDP figures from falling even more and for longer could not be denied, but with the lack of the expected positive correlation between the amount of money lent out by the Fed to the banking sector and the recovery in the economy.

Finally, once the monetary policy objectives have been achieved, the new monetary conditions may offer room to the central bank to either maintain interest rates steady or even reverse the sign of policy by means of an interest rate variation in opposite direction to the previous one.

[17] This analysis is compatible with the findings of Taylor, 2009, and Selgin *et al.*, 2015.

The corresponding portfolio adjustment is coherent with the positive correlations between the lagged (two and three quarters) interest rate and the monetary aggregates (in equations 7a and 8a), as well as for those between prices (correlation 2c) and the business cycle (correlation 9b).

Figure 4. Figures of some recursive correlations between cyclical common factors (blue lines) and of their mean levels (red lines) in expansions and recessions in the US. Period: 1960Q1-2014Q4.

Figure 4.1. $\rho_t(c_t^{bc}, c_t^{pr})$ (9a)

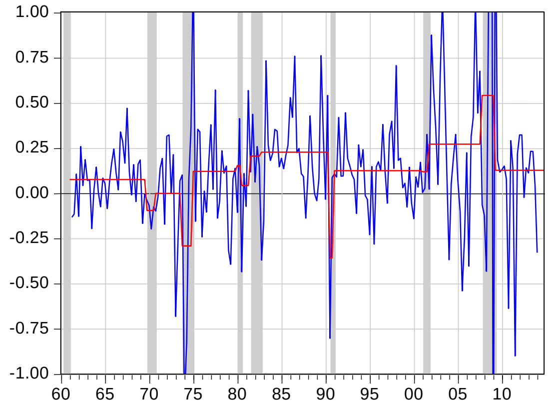


Figure 4.2. $\rho_t(c_t^{st\_\mathrm{int}}, c_t^{pr})$ (4a)

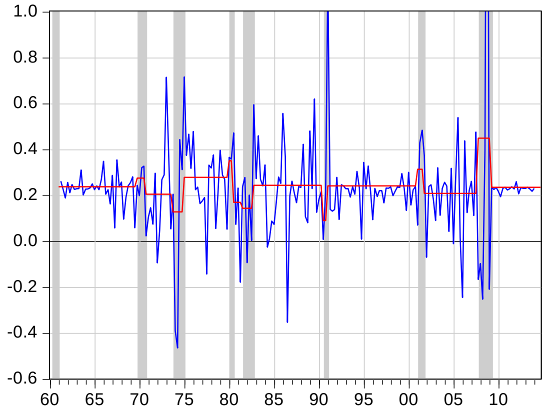


Figure 4.3. $\rho_t(c_t^{\mathrm{int}}, c_t^{pr})$ (6b)

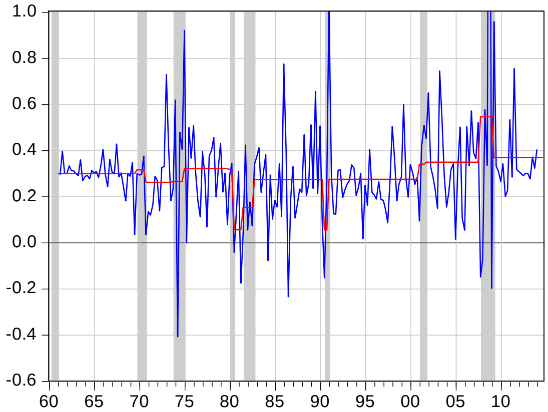


Figure 4.4. $\rho_t(c_t^{\mathrm{int}}, c_t^{bc})$ (5b)

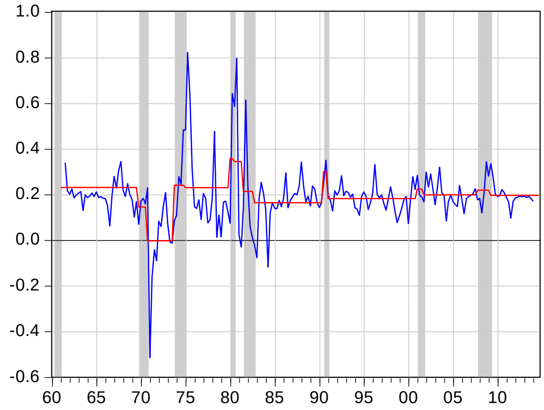


Figure 4.5. $\rho_t(c_{t-2}^{st\_\mathrm{int}}, c_t^{bc})$ (3a)

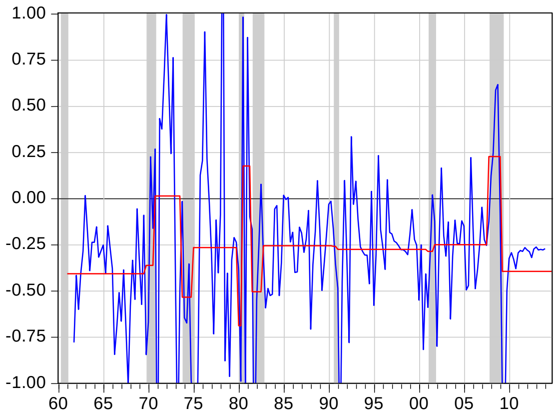
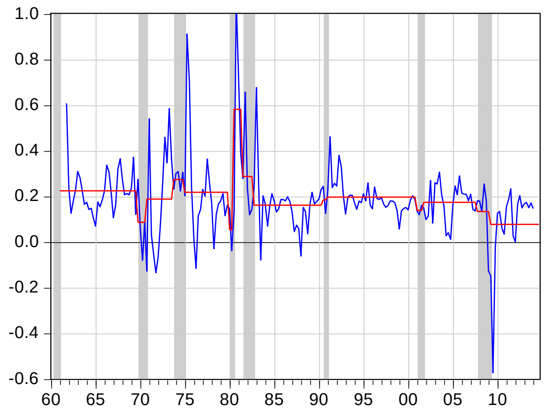


Figure 4.6. $\rho_t(c_{t-1}^{m}, c_t^{bc})$ (1a)



4. The last cycle, housing prices and the core information set

Having registered an exponential growth of broad money (M3) since 2005 until the outbreak of the GFC (even double digit rates of growth), one would expect a booming in the demand (and thus in the prices) for some real and financial assets. Within the explanation of the monetary transmission mechanism into the economy previously analysed, the mere focus on just a selection of consumption goods and services' prices such as those included in the CPI may offer just a partial explanation of the adjustments taken place in the market, and ultimately could be misleading as a guide to make monetary policy decisions. The relation between money growth and changes in prices in the economy take place through banks, non-financial companies and households' portfolio adjustments (see Friedman and Schwartz, 1963 and Congdon, 2005); so in case of an excess (shortage) of liquidity in the economy, it will be followed by an increase (decrease) in the demand of alternative assets such as fixed interest rate bonds (both public and private), equity, real assets (residential property amongst them) and finally an increase in the demand of goods and services. Endogenous money creation as a consequence of the targeting of the Fed Funds rate from 1983 according to the implicit following of a Taylor's type rule does not prevent from money changes being the ultimate determinant of price changes in the long term. As seen above, the estimated cyclical common factor obtained from the monetary aggregates is highly correlated with interest rate variations, and thus the explanation of the expected effects of monetary policy changes on the economic activity and prices.

In our view, housing prices, as a major representative of real asset prices, must be considered into the core information set used by central banks to make monetary policy decisions in view of maintaining monetary stability over the long term, along with CPI and financial assets prices. Housing is in itself a quite relevant part of the GDP in modern economies but, most importantly, it has significant spillover effects on the rest of the economy as experienced in quite several countries during the GFC. Movements in housing prices affect households' wealth, and together with other real estate assets, the balance sheets of firms and financial institutions. When financial imperfections are present, by means of a financial accelerator mechanism (e.g. Bernanke and Gertler, 1989), housing prices movements translate on to consumption and investment decisions as they affect agents' solvency ratios and their ability to borrow, which will ultimately amplify business cycle oscillations. Information concerning the real estate sector is fundamental when conducting monetary policy both as a signal of real asset inflation pressures and monetary instability that could act as a business cycle destabilizer, and for its importance as a policy transmission mechanism.[18]

As evidenced in the recent crisis, we argue that the rapid and excessive growth in broad money in most advanced economies from 2004 to 2007 (see Taylor, 2009; Castañeda and Wood, 2011; Selgin *et al*., 2015; Cendejas *et al*., 2014ab) contributed to an unsustainable growth in borrowing and in residential property prices. True, a too loose monetary policy, specifically from the mid-1990s until the outbreak of the recent crisis, was not observed in CPI prices but the excess of liquidity in banks, non financial firms and households' portfolios did reflect in other prices such as notably in asset prices; we will analyse the correlation between the cycle and these other prices in the economy below.

By analysing the correlations between the cyclical component of housing prices and the cyclical common factors, an outline of housing price[19] variations along the cycle is obtained. For this purpose, the univariate version of model (1) is estimated (Cendejas *et al.*, 2015)[20] the annual growth rates of the House Price Index, GDP, monetary aggregates, interest rates and CPI are plotted in Figure 5, and the cross correlations between the cycle component of the House Price Index, c_t^{house}, and the common factors c_t^{bc}, c_t^{pr}, $c_t^{\mathrm{st\_int}}$, c_t^{int} and c_t^{m}, are shown in Table A.2.

Quite remarkably, from 1975 housing prices have continuously increased year on year in the US with only the exception of the Great Recession years (Figure 5.1). The recessions of the beginnings of the 1980s and the 1990s caused a reduction in the growth rates of residential prices but not even that of 2001. Even more, from 1991 to 2006 housing prices have been increasing at an even growing trend which accelerated in 2003, the year when we argue the Fed policy started to run a too loose monetary policy, and finally stopped abruptly in 2006 and plummeted. Comparing housing prices and CPI rate of inflation (Figure 5.4), it can be seen how the rough parallelism between the two series is broken around 1997. From this year CPI inflation continued its moderate trend in the range of 2-4% per annum but housing prices diverted, reaching a 11% peak annual rate of growth in 2005. From 1991 until 2003, the growing trend in housing inflation runs in parallel with that of the monetary aggregates as seen in Figure 5.2. In the full sample (see Table A.2 in the Appendix) the business cycle factor, c_t^{bc}, anticipates with a lead of two and three quarters the cycle component of residential prices, c_t^{house}

[18] See for example Caruana (2005), Mishkin (2011), and Xu & Chen (2012).
[19] All-Transactions House Price Index for the United States, US Federal Housing Finance Agency.
[20] The estimated variances for the period 1975Q1-2014Q4 have been $\sigma_\varepsilon^2 = \underset{(0.0375)}{0.2225}$ and $\sigma_\eta^2 = \underset{(0.0392)}{0.1476}$.

(see correlation 1a in Table A.2). A positive contemporaneous correlation is found between the variations in housing inflation c_t^{house} and the monetary factor c_t^m as expected (see equation 2a), so we can see how more and more money in the market resulted in higher residential property prices. However, some negative contemporaneous correlations with a lead and a lag of two quarters (equations 2a and 2b) are also found. These could be related with the policy response to inflation and the lag in respect to the business cycle factor (c_t^{bc}), the former, and the policy reversing correlations, the latter.

Figure 5. US annual growth rates of the House Price Index, GDP, monetary aggregates, interest rates and CPI. Period: 1975Q1-2014Q4

Figure 5.1. Annual growth rates of House Price Index and GDP

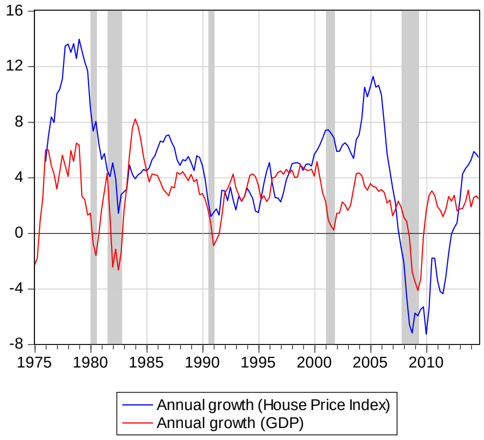


Figure 5.2. Annual growth rates of House Price Index, M2 and M3

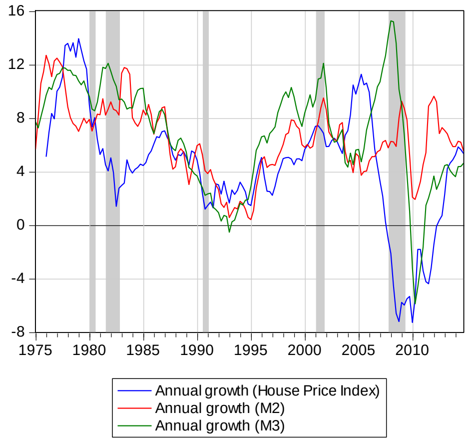


Figure 5.3. Annual growth rates of House Price Index, Fed Fund and 10y interest rates

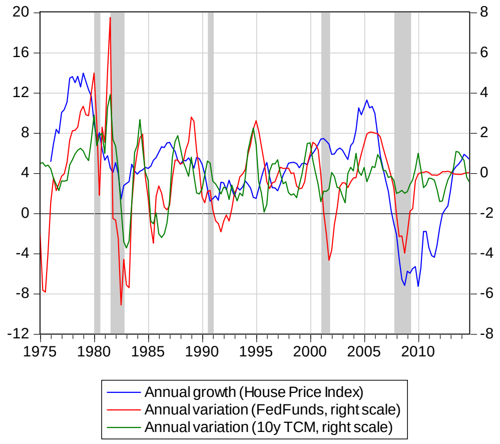
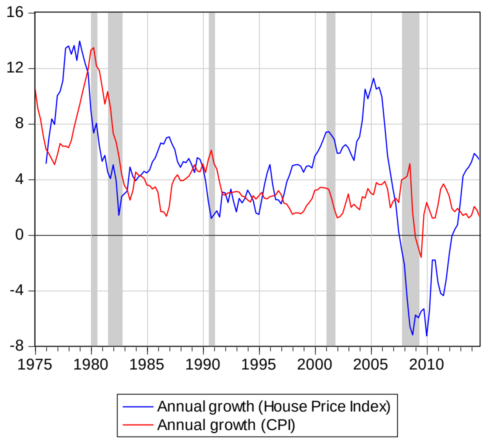


Figure 5.4. Annual growth rates of House Price Index and the CPI



As to interest rates and house prices, interest rates common factors (both $c_t^{\mathrm{st\_int}}$ and c_t^{int}) affect c_t^{house} with a negative sign and with a long delay (see equations 3a and 4a above) as expected, since a tightening in monetary policy (higher interest rates) would tend diminish the rate of growth of house prices. Contemporaneous positive correlations between c_t^{house} and c_t^{m}, and negative between c_t^{house}, c_t^{int} and c_t^{pr} are mutually coherent with our previous analysis of the policy response of the Fed in case of a deviation form its targets: an inflationary shock causes the Fed to raise interest rates, reducing monetary aggregates and also housing inflation. So the negative correlation between housing inflation and good and services inflation (c_t^{house} and c_t^{pr}) is a consequence of the Fed's policy response, mainly driven by CPI inflation. So it is clear that, rather than just an explanatory factor of CPI inflation, at least from the mid 1990s onwards, housing prices have conveyed different information from the CPI, which gives ground to use it as a separate set of useful information on real asset prices not contained in the CPI.

Monetary policy regimes and inflation

In the literature preceding the Great Recession, the thesis that it was an improvement in monetary policy what mainly contributed to the Great Moderation received considerable attention; although the prevailing view was that the changes taking place in the economy affected not so much the propagation mechanism but the different size and sign of the disturbances affecting the economy, with either a private or a policy origin. In this line, Sargent *et al.* (2006) attributes this inflexion to policymakers updating beliefs on the Phillips curve and its limits, which would have changed enough to account for Volcker's conquest of US inflation in the early 1980s. Shocks in the 1970s altered the monetary authority's estimates and made it misperceive the trade-off between inflation and unemployment causing the sharp rise in inflation in those years. Qualitative support for this empirical finding can be found in Romer and Romer (2004) that analyzes the importance of the Federal Reserve Chairman's beliefs at the time on monetary policy performance. According these authors, the key determinants of policy success have been policymakers' views on how the economy works and what monetary policy can do and cannot do. They find that the well-tempered monetary policies of the 1950s, 1980s and 1990s stemmed from a conviction that inflation had high costs and few benefits, together with more realistic views on the estimate of the sustainable level of unemployment in the economy and the final determinants of inflation. In contrast, the profligate policies of the late 1960s and 1970s stemmed initially from a belief in a reliable trade-off between inflation and unemployment, and later on from a highly optimistic estimate of the natural rate of unemployment on the one hand, and a highly pessimistic estimate of the sensitivity of inflation to slack on the other.

A rough relationship between monetary regimes and Fed's mandates is also found in Sims and Zha (2006). These authors find that the multivariate regime-switching model that best fits in US data is the one with changes only in disturbance variances. Amongst the changing coefficients model the best fit corresponds to the one with changes in the monetary policy equation. The three regimes found match with periods where there is agreement on monetary policy actually differed (a four regime occurs only for some isolated months). According to their distinctive features these regimes are named after their chairman at the time Burns, Volcker and Greenspan, although their time spans do not coincide exactly with their terms in office. Primiceri (2005) concludes that both systematic and non-systematic monetary policy reactions to the main central banks' mandates have changed during the previous forty years. Systematic responses of the policy interest rate to inflation and unemployment exhibited a trend toward a more aggressive behaviour, despite remarkable oscillations over time. However, these oscillations had a negligible effect on the rest of the economy, as the role played by exogenous non-policy shocks seemed more important than interest rate policy changes in explaining the high inflation and unemployment episodes. Stock and Watson (2003a) also shared an eclectic view on the effects of policy and 'good luck' shocks. On the contrary, other authors attribute a fundamental role to the change of the implicit monetary policy rule run by the Fed under Volcker and Greenspan mandates in achieving a reduction both in the volatility of output growth and inflation along the cycle. For example, Clarida *et al.* (2000) show how the interest rate policy in the Volcker-Greenspan period was much more sensitive to changes in expected inflation than in the pre-Volcker period, being the new monetary policy rule more stabilizing over the medium and long term. And Bae *et al.* (2012), by means of a Markov-switching model, identify five regimes roughly coinciding with different governors' mandates, except for Greenspan's, and find that the changes in the Fed's responses to inflation and output gap, play an important role in identifying these regimes.

As far as we are concerned, the analysis made above with our estimates of the cyclical components and correlations of different real and monetary variables points at considering inflation, *broadly defined*, as the link between changes in the business cycle and in monetary policy. For the period before the Great Recession, our analysis roughly coincides with the empirical studies mentioned in the dating of the cycle and in their characteristic features. The new policy of the first years of Volcker's mandate points out the beginning of a new monetary regime in which inflation, as measured by the CPI, receives a greater weight in the running of an implicit Taylor's type rule by the Fed, after some years dominated by monetary accommodation to inflationary pressures. The recursive correlations have shown Fed's policy changes as a consequence of the inflationary shocks of the early 1970s and when the inflationary trend in reversed in the early 1980s. From 1984 onwards, the analysis of the cyclical components allows us to point at some of the characteristic features of the Great Moderation years: that is, a greater persistence and lower volatility of the short term interest rates which are linked to the new instrumental variable used by the Fed, the Fed Funds, once the monetary growth targets were abandoned; a corresponding greater sensibility of the long term interest rates to the Fed Funds resulting in a more effective monetary policy in the long term; the greater and greater endogeneity of the monetary aggregates; and a lower overall volatility of the business cycle.

The success of the Volcker-Greenspan regime in reducing inflation and the improved world-wide supply side conditions, resulted in the combination of steady economic growth with inflation rates considered as definitively moderate henceforth. In this benign economic context, with the aim of avoiding stock market corrections and eventual declines in the business cycle, the Fed conducted interest rate reductions and thus supported even more the already existing growth expectations in markets at the cost of destabilizing financial and real assets prices along the second half of the 1990s and especially after the dot.com bust and the terrorist attacks in 2001. As a result monetary policy goes from the moderate disinflationary stance of the 1983 to 2000 period to other more loose/inflationary lasting until 2007. Until 2005, interest rates remained very low in spite of the increase in real estate asset prices and their increasing weight and potential destabilizing impact in the balance sheets of major investment banks and other financial institutions. For many years, and certainly before the outbreak of the GFC, this process was not considered as a fundamental risk for financial stability as price stability defined in terms of the CPI was taken as tantamount to both sustainable economic and financial stability. No broad monetary aggregate was taken explicitly into account in the shaping of policy decisions although they were informing timely on the more and more overall inflationary environment affecting the economy, perhaps not consumption markets yet but assets' prices first. Anyhow, and increase in CPI inflation finally took place in 2007 and the Fed began to rise the FF rates. This was one of the main triggers of the recent financial crisis that had a truly global dimension. The monetary regime of the Great Moderation years made then clear its flaws and limits at the time in which inflation manifested mainly in asset prices and not that much on while CPI inflation. The adoption of non-conventional measures (QE) and the virtually zero interest rate policy by the Fed since 2008 on inaugurated a new monetary regime whose particular features and ultimate effects are yet to be fully determined.

5. Policy implications and concluding remarks

Nowadays neither central banks nor other policy makers deny the correlation between changes in the amount of money in the economy and changes in the price level over the medium to the long term; quite the contrary, this is one of the founding laws of monetary economics emphasized by central banks officials in public speeches and even included in the constitution of modern banks (see the Statutes of the ECB) or in the reform of the existing banks (see the Bank of England Act 1998). However, this correlation between the growth in money and changes in prices is hardly applied in practice in the framing and in the communication of central banks decisions. Firstly, the time horizon of monetary policy is usually much shorter than the long term, that time span compatible with the fully transmission of monetary impulses onto prices, and central banks rather commit to maintaining inflation (but not price) stability in 1-2 years time. This shorter time horizon requires more monetary activism and increases the likelihood of making policy errors, resulting in a more destabilizing monetary policy. But even more relevant, as regards the measurement of the overall price level in the economy, the Fed and most central banks primary use an index such as the CPI which excludes by its definition real and financial assets prices. This means leaving a significant part of the prices of the economy out of the scope of the central bank policy. There has been a long debate on this question for decades now (Wynne, 2008) and those in favour of adopting a CPI target claim the difficulty, if not the undesirability, of stabilizing financial and real assets prices, rightly claiming that central banks cannot determine the 'true' fundamental or sustainable price of those assets. True, we should not give the central banks a target which is not under their full control, and which fundamental value is highly controversial if not impossible to determine. However this does not mean we should not take much more into account all prices, and not just CPI prices, in the framing of monetary policy by incorporating them into a much broader core set of policy indicators.

The absence of a more comprehensive monetary strategy by the Fed since the end of the fixed exchange rate system in the 1970s has resulted in a case-by-case decision making policy which has contributed to a great extent to the genesis of the GFC. Within this theoretical and empirical approach, in this paper we have analysed the relationship between the business cycle, prices (of both goods and services, and real and financial assets), interest rates and monetary aggregates in order to identify cyclical regularities to draw monetary policy implications. In our view, those variables constitute the core information set for the Fed suitable to conduct a monetary policy committed to low inflation and output stability as well as monetary stability along the business cycle.[21] Some critical episodes in the past such as the oil crises changed the existing monetary policy strategy at the time and entailed the adoption of new indicators and economic findings not considered heretofore, thus resulting in an improvement in monetary policy decisions. For example, the high inflation episodes of the 1970s made the Fed, under Volcker's mandate, to monitor monetary aggregates closely and to acknowledge the instability of the Phillips curve due to the incorporation of inflation expectations. More recently, the GFC has put back on the table real estate prices, financial instability and bank regulation, and both supranational bodies such as the Bank of International Settlements and national regulators are devoted to apply the so-called macroprudential policies, those aimed at maintaining financial stability over the long term. However the recent and sudden emphasis giving to monetary growth and overall prices in the economy, so far central banks have not been explicitly incorporated a clear strategy as regards the framing and the communication of monetary policy decisions, which lacks in transparency in the decision making process and in the information provided to market agents to form their expectations.

In view of the accumulated experience available since the end of the Bretton Woods monetary system, we believe a change in the monetary strategy of central banks is needed in order to adopt a more robust nominal anchor to drive monetary policy decision over the medium and long term. To this end, we offer in this paper evidence to support the use of a wide range of output, monetary and price indicators as a core set of information to better preserve monetary stability over the long term. In particular, given the cyclical correlations found in the paper the assessment of inflation should be made more broadly to take into account not just CPI prices but other prices in the economy such as financial and real asset prices. As proven in the recent financial crisis, achieving CPI price stability has not been enough to maintain monetary and financial stability over the long term. The actual use of this broader set of indicators could be compatible within the main elements of the current monetary setting of major central banks, one in which the bank announces an inflation target in terms of a well-known and easy to interpret CPI, along with a broader selection of monetary indicators and prices that could be taken and used as an index of monetary and financial stability over the long term. In fact, after the collapse of markets in the autumn of 2008, the so-called macro-prudential policies are at their heyday and major central banks are much more involved in designing policies and adopting new regulation to preserve financial stability. In this line, the announcement of a core set of indicators, broader than just CPI prices and the output gap, would contribute to familiarise the public to a new metric to assess monetary and financial stability in a more transparent fashion.

[21] Exchange rate and current account balance ought to be included in the *core information set*. Indeed, when interest rate has reached a zero level, monetary policy can still be effective by means of a depreciation of the currency (McCallum, 2000; Yates, 2004).

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Data sources

Except otherwise indicated, Federal Reserve Bank of St. Louis database (https://research.stlouisfed.org/fred2/). When necessary, original monthly figures have been transformed in quarterly data by averaging.

Monetary aggregates: Monetary Base, seasonally adjusted, Federal Reserve Bank of St. Louis. M1 Money Stock, seasonally adjusted; M2 Money Stock, seasonally adjusted; M3 Money Stock, seasonally adjusted. Board of Governors of the Federal Reserve System (US). M3, from 2006Q1 until 2014Q4, Shadow Government Statistics.

Interest rates: Effective Federal Funds Rate; 3-Month Treasury Bill, Secondary Market Rate; 1-Year Treasury Constant Maturity Rate; 3-Year Treasury Constant Maturity Rate; 5-Year Treasury Constant Maturity Rate; 10-Year Treasury Constant Maturity Rate. Board of Governors of the Federal Reserve System (US).

GDP: Real Gross Domestic Product, billions of chained 2009 dollars, seasonally adjusted. US. Bureau of Economic Analysis.

IPI: Industrial Production Index, seasonally adjusted. Board of Governors of the Federal Reserve System (US).

Dow Jones Industrial Average. Source: Samuel H. Williamson, “Daily Closing Values of the Dow Jones Average in the United States, 1885 to Present”, Measuring Worth, 2015. URL: http://www.measuringworth.com/DJA/.

Prices: Implicit Price Deflator (Gross Domestic Product), seasonally adjusted, US. Bureau of Economic Analysis; Consumer Price Index for All Urban Consumers: All Items, seasonally adjusted, US. Bureau of Labor Statistics; Producer Price Index: All Commodities, US. Bureau of Labor Statistics; Crude Oil Prices: West Texas Intermediate (WTI) - Cushing, Oklahoma, spot prices, US. Energy Information Administration (until 1985: spot oil price, West Texas Intermediate, Dow Jones & Company); All-Transactions House Price Index for the United States, US. Federal Housing Finance Agency.

Table A.1. Full sample (1960Q1-2014Q4) cross correlations between cyclical common factors.

1.Business cycle cf and monetary aggregates cf

1a 1b

CF_BC,CF_M(-i)	CF_BC,CF_M(+i)	i	lag	lead
		0	0.0029	0.0029
		1	0.1451	-0.2525
		2	0.1425	-0.0047
		3	0.0670	0.0571
		4	-0.0623	0.0287
		5	-0.0460	-0.0332
		6	0.0511	-0.0096
		7	0.0176	-0.0092
		8	-0.0001	-0.0308

2. Prices cf and monetary aggregates cf

2a 2b, 2c

CF_PR,CF_M(-i)	CF_PR,CF_M(+i)	i	lag	lead
		0	-0.3243	-0.3243
		1	0.0566	-0.2013
		2	0.1366	0.2404
		3	-0.0609	0.0600
		4	0.0230	-0.0647
		5	-0.0257	0.1070
		6	-0.0240	0.0116
		7	-0.0253	-0.0519
		8	0.0461	0.0445

3. Business cycle cf and st interest rate cf

3a 3b

CF_BC,CF_INT_ST(-i)	CF_BC,CF_INT_ST(+i)	i	lag	lead
		0	0.1503	0.1503
		1	-0.3349	0.1322
		2	-0.3401	-0.0050
		3	-0.0218	0.0954
		4	-0.0349	-0.0294
		5	-0.0392	0.0475
		6	0.0024	0.1783
		7	-0.0310	-0.0125
		8	0.0313	-0.1155

4. Prices cf and short term interest rate cf

4a

CF_PR,CF_INT_ST(-i)	CF_PR,CF_INT_ST(+i)	i	lag	lead
		0	0.2241	0.2241
		1	0.0694	0.0793
		2	-0.0402	0.0390
		3	-0.0187	0.0657
		4	0.0161	-0.0058
		5	-0.0085	0.0092
		6	-0.0244	0.0668
		7	-0.0837	-0.0248
		8	-0.1440	0.0310

5. Business cycle cf and interest rate cf

5a 5b

CF_BC,CF_INT(-i)	CF_BC,CF_INT(+i)	i	lag	lead
		0	0.2305	0.2305
		1	-0.2760	0.0664
		2	-0.3258	-0.0367
		3	0.0094	0.0840
		4	-0.0251	0.0128
		5	-0.0275	-0.0284
		6	0.0995	0.0997
		7	-0.0401	0.0625
		8	-0.0283	-0.1849

6. Prices cf and interest rate cf

6a 6b

CF_PR,CF_INT(-i)	CF_PR,CF_INT(+i)	i	lag	lead
		0	0.2573	0.2573
		1	-0.0076	0.0493
		2	-0.1583	0.0128
		3	0.0289	0.0491
		4	0.0456	-0.0135
		5	-0.0758	0.0201
		6	-0.0337	0.0783
		7	-0.0549	0.0133
		8	-0.0760	0.0733

7.Monetary aggregates cf and st interest rate cf

7a, 7b

CF_M,CF_INT_ST(-i)	CF_M,CF_INT_ST(+i)	i	lag	lead
		0	-0.3118	-0.3118
		1	-0.1967	0.0253
		2	0.1527	0.0125
		3	0.1414	0.0410
		4	0.0861	-0.0238
		5	-0.0551	-0.1078
		6	0.0021	0.0695
		7	0.1112	0.0227
		8	0.1669	0.0141

8.Monetary aggregates cf and interest rate cf

8a, 8b

CF_M,CF_INT(-i)	CF_M,CF_INT(+i)	i	lag	lead
		0	-0.3291	-0.3291
		1	-0.3091	0.0448
		2	0.3127	0.0098
		3	0.1386	0.0529
		4	-0.0039	0.0050
		5	0.1048	-0.0591
		6	0.0516	0.0302
		7	0.0078	-0.0107
		8	0.0654	0.0126

9.Prices cf and business cycle cf

9a 9b

CF_PR,CF_BC(-i)	CF_PR,CF_BC(+i)	i	lag	lead
		0	0.1140	0.1140
		1	0.1237	-0.0503
		2	-0.0721	-0.1047
		3	-0.0668	-0.1318
		4	0.0688	-0.0967
		5	0.0498	0.0250
		6	-0.0063	0.0555
		7	0.0572	-0.0251
		8	-0.0225	-0.0051

Table A.2. Full sample (1975Q1-2014Q4) cross correlations between the cyclical component of the housing prices and the cyclical common factors.

1. c_t^{house} and business cycle cf

1a C_HOUSE,CF_BC(-i) 1b C_HOUSE,CF_BC(+i)

i	lag	lead
0	-0.0442	-0.0442
1	0.0472	0.0682
2	0.2024	0.1011
3	0.1702	0.0617
4	-0.0553	0.0364
5	-0.0780	-0.1160
6	-0.0392	-0.0936
7	0.0410	-0.0121
8	0.1552	0.0182

2. c_t^{house} and monetary aggregates cf

2a C_HOUSE,CF_M(-i) 2b C_HOUSE,CF_M(+i)

i	lag	lead
0	0.2165	0.2165
1	0.0169	0.0039
2	-0.2379	-0.2442
3	-0.1444	-0.0803
4	0.0638	0.0871
5	0.0694	-0.0048
6	0.0490	0.0188
7	0.0636	0.0246
8	-0.0091	-0.0262

3. c_t^{house} and short term interest rate cf

3a C_HOUSE,CF_INT_ST(-i) 3b C_HOUSE,CF_INT_ST(+i)

i	lag	lead
0	-0.0794	-0.0794
1	-0.0664	0.0217
2	0.0138	0.0795
3	-0.0962	0.1453
4	-0.2678	0.1246
5	-0.2159	0.0102
6	-0.1715	0.0741
7	-0.1411	0.1892
8	-0.0622	0.1560

4. c_t^{house} and interest rate cf

4a C_HOUSE,CF_INT(-i) 4b C_HOUSE,CF_INT(+i)

i	lag	lead
0	-0.2043	-0.2043
1	-0.0919	-0.0776
2	0.0953	0.0268
3	-0.0141	0.0992
4	-0.2151	0.1295
5	-0.1543	0.0390
6	-0.0877	0.0254
7	-0.1382	0.0881
8	-0.1122	0.1174

5. c_t^{house} and prices cf

5a C_HOUSE,CF_PR(-i) 5b C_HOUSE,CF_PR(+i)

i	lag	lead
0	-0.2427	-0.2427
1	-0.1745	0.0601
2	0.1382	0.2283
3	0.1352	0.1404
4	-0.0529	0.0823
5	-0.0894	0.0044
6	-0.0968	-0.0746
7	-0.0744	0.0012
8	0.0568	0.0779

Table Summary

Period	Business cycle phase	Annual GDP Growth $\bar{x}$ (σ)		Annual CPI Inflation $\bar{x}$ (σ)	Federal funds $\bar{x}$ (σ)	10y bonds $\bar{x}$ (σ)	Recursive correlations (mean values)		
							$\rho(c_t^{\mathrm{bc}}, c_t^{pr})$ (9a)	$\rho(c_t^{\mathrm{st\_int}}, c_t^{pr})$ (4a)	$\rho(c_t^{\mathrm{int}}, c_t^{pr})$ (6a)
1961Q1-1969Q3	Expansion	4.8 (2.8)		2.6 (1.7)	4.2 (1.7)	4.7 (0.8)	7.4	23.6	32.5
1969Q4-1970Q3	Recession	-0.2 (2.3)		5.5 (1.0)	8.0 (1.0)	7.5 (0.2)	-9.7	27.4	33.6
1970Q4-1973Q3	Expansion	5.0 (4.7)		5.0 (2.0)	5.6 (2.0)	6.4 (0.4)	-0.2	20.4	27.7
1973Q4-1974Q4	Recession	-2.5 (3.2)		10.9 (0.9)	10.4 (1.2)	7.4 (0.5)	-29.2 (Oil shock)	12.6	34.6
1975Q1-1979Q4	Expansion	4.2 (4.2)	Inflationary trend	8.2 (2.7)	7.1 (2.5)	8.2 (0.8)	12.0	27.7	35.9
1980Q1-1980Q2	Recession	-4.4 (6.6)		10.5 (1.6)	13.9 (1.7)	11.2 (1.1)	15.3	34.9	32.3
1980Q3-1981Q2	Expansion	0.1 (5.6)		0.3 (1.9)	15.0 (3.5)	12.5 (1.2)	4.1	16.8	-0.8
1981Q3-1982Q3	Recession	-2.1 (4.7)		4.8 (2.8)	14.2 (2.3)	14.1 (0.6)	20.4	14.2	12.7
1982Q4-1990Q2	Expansion	4.2 (2.2)	Disinflationary trend	3.8 (1.7)	8.3 (1.3)	9.6 (1.7)	22.6	24.3	26.9
1990Q3-1990Q4	Recession	-2.6 (2.5)		4.9 (0.1)	8.0 (0.3)	8.5 (0.2)	-35.9 (Oil shock)	8.9	2.2
1991Q1-2000Q4	Expansion	3.6 (2.0)		2.7 (0.8)	5.0 (1.1)	6.4 (0.8)	12.4	24.0	28.0
2001Q1-2001Q3	Recession	0.7 (1.9)	“the ‘NICE’ decade”	1.2 (1.4)	4.5 (1.1)	5.1 (0.2)	11.8	31.3	35.4
2001Q4-2007Q3	Expansion	2.8 (1.5)		2.9 (1.7)	2.8 (1.7)	4.5 (0.4)	27.1	20.7	**40.5**
2007Q4-2009Q1	Recession	-2.9 (4.0)		0.9 (6.1)	2.1 (1.6)	3.6 (0.5)	**54.1**	**44.8**	**51.7**
2009Q2-2014Q4	Expansion	2.3 (1.9)		1.9 (1.4)	0.1 (0.0)	2.7 (0.6)	12.6	23.4	**45.9**